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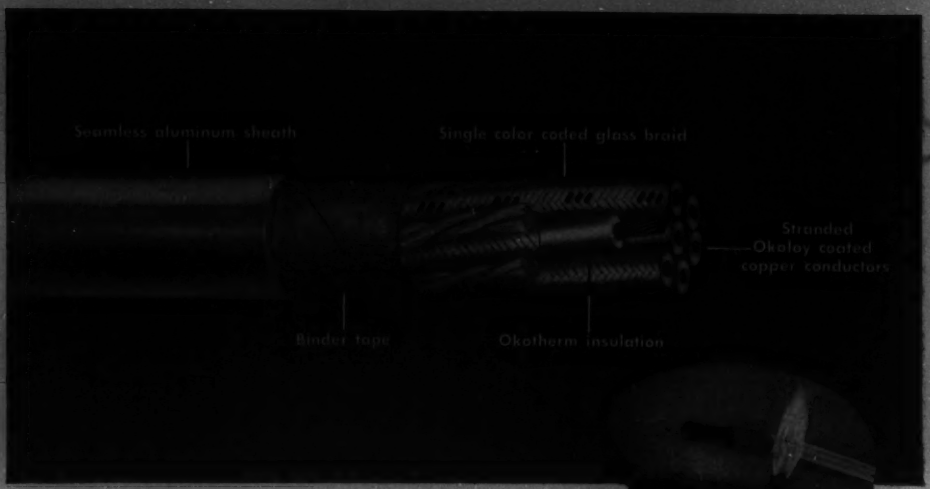

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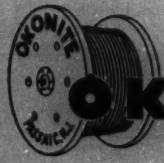

OKONITE OKONITE SINCE 1878 *insulated cables*

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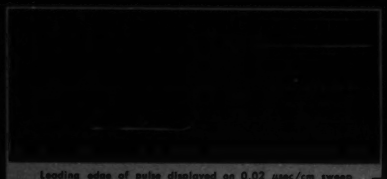
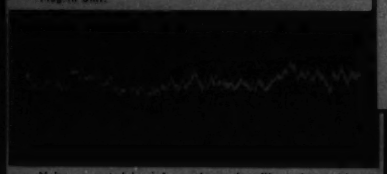
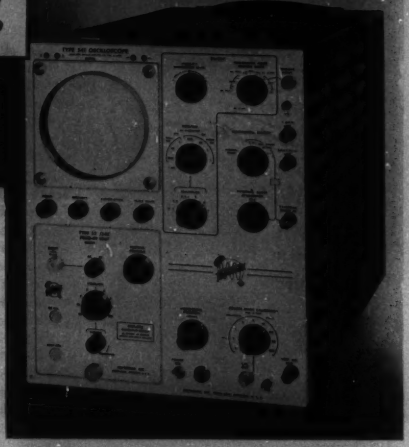


Leading edge of pulse displayed on 0.02 μsec/cm sweep shows clean response of the Type 541 with the Type 53/54K Plug-in Unit.



Noise generated by a 1-megohm carbon-film resistor with 45 v dc applied, displayed on 2 msec/cm sweep of the Type 541 with the Type 53/54E Plug-in Unit at 50 μv/cm sensitivity.



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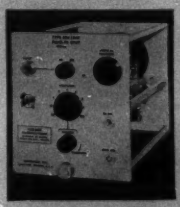

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STATE OF THE ART

M. D. HOOVEN
PRESIDENT AIEE

In his Winter Meeting address, President Hooven discusses the phenomenal changes taking place in our society as the result of our rapid technological advances. A glimpse into the future, based on today's progress, is presented.

REPORTING ON THE PROGRESS of the art and science of electricity at this moment in history is a task to defeat an intellectual Hercules. Have you ever stood on the platform waiting for the 8:15 to take you to work when a mile-long 60-mile-an-hour freight thunders through the station inches from your nose? Could you read off the car numbers? Can you—each of you expert in some phase of the art—grasp the detail of all that is happening in electrical engineering today? The volume of projects, speed of accomplishment, and the tremendous impact of community change leave the observer mentally breathless. Remaining, however, is the deep impression of a lot of things going somewhere fast. In the first place, it is apparent that the electrical engineer ministers not only to the great common public, but even more specifically to his sister branches of technology. It is apparent that the traditional services of the electrical engineer in the transfer of information and energy have expanded so that the entire intellectual world of science and industry awaits his services. Newly oriented educational courses are being given to our young men. The engineering world is changing. The electrical engineer can now do almost everything except foretell the future, although for 30 years he has not been doing too badly in power load and communication traffic forecasts; perhaps he can do more soon.

If forecasting the future is extrapolation of the past (with, of course, all the data factored in), he may not be too far from phenomenal prophecy. Mass production of memory cells for computers is now routine. Perhaps in the future, with great banks of memory cells, the electronic brain will give us many more answers than those attributed to the Delphic Oracle. But why speculate? A quick review of the present gives enough of an indication of the fact that we are in the midst of astonishing developments and are on the brink of more.

The transistor has continued to insinuate itself into every nook and cranny of the art. From entertainment-providing portable radios, through relays for power transmission, to the deadly serious air-borne computers used by the military, the transistor with its light weight and low use of energy has given its services to all sorts of electrical and electronic devices. Important contributions to development are being made in the whole field of semiconductors.

Magnetic amplifiers also help in the direction of miniaturization and the development of free-from-maintenance devices as do the new products in the metallic rectifier field. On the other end of the scale, huge rectifiers drive locomotives. Energy supply and transfer devices are becoming bigger and better. Generators of over 300,000-kva capacity are not uncommon and 1/2-million-kva machines are in sight. These are, of course, made possible by the use of gaseous or liquid coolants. The 300,000-kva transformers are already being left behind. The January issue of *Electrical Engineering* shows a picture of a motor rated over 100,000 horsepower. This single motor represents an output equal to the total sustained muscle power of the whole population of the United States in Benjamin Franklin's day.

Text of the presidential address presented at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956.

M. D. Hooven is electrical engineer, Public Service Electric and Gas Company, Newark, N. J.

Circuit breakers no longer seem to be a limiting feature, 10-million kva being a common rating with higher ratings in sight. The trend of power supply system development is toward transmission and distribution of greater amounts of energy over more widely dispersed areas. Higher voltages are in order with 300- to 400-kv transmission being utilized, and even higher voltages planned.

The rapid increase in the use of electric energy is paralleled by a similar rapid increase in the use of electrical communications. It is part of the same pattern of a rising standard of living. Can anyone imagine a Mrs. Franklin of today's Philadelphia waiting many months to learn from London whether she should try blue wallpaper? The modern Mrs. Franklin without a second thought would put in a Philadelphia-London call and settle the matter of color for the living room in minutes. Daughter Sally Franklin's wedding would not await the uncertain interchange of ideas in letters delivered by friendly travelers. The words of wit and wisdom and philosophy of a Franklin of today could be spread worldwide the moment they were uttered. And communication is still improving.

Progress in communications has been on all fronts—telegraph, telephone, radio, and their various interrelationships. Like power systems, communication systems are becoming more tremendous and at the same time are using smaller and more sensitive control devices. The tropospheric scatter system for radio opens new fields. Radio is increasing its services to transportation, the new toll highways being largely controlled by radio; and great strides are being made in radio and radar aids to air navigation. Train signal systems and ship navigation and control projects show similar progress. Facsimile equipment for use on wire or wireless becomes better. Color television programs have increased 400 per cent. Of 364 network stations, 300 are equipped to transmit color. Schools and industries use closed-circuit television. Broadcasting stations, like the power stations before them, are becoming increasingly automatic. Taped programs are becoming common.

Industry follows the same pattern of bigger, better, and more automatic operations. The great steel industry, symbol of size, uses transistors and magnetic amplifiers for fine control. The new steel plants, such as the Fairless Plant of the United States Steel Corporation in the Delaware River Valley, are replete with electricity supply and electronic control devices. Every production engineer everywhere is occupying himself with automation. The carrying of heat to a proper place whether for welding, for stress relieving, or for processing is an electrical function. New accomplisments are being made with lighting. Lighting, like the other children of electrical engineering, is rapidly expanding; total lumen hours having tripled in 10 years. A 200-million-candlepower short-arc mercury searchlight is being used at airports. On the other end of the scale low power, completely diffused illumination through electrically excited paint is under development.

With today's electrical accomplishments so far beyond anything that yesterday dreamed of, who is able to unleash an imagination competent to picture tomorrow? Benjamin Franklin, whose 250th birthday we have just celebrated, was not afraid of speculation. The prophet of electrical engineering, admitting a degree of chagrin for having been unable to produce anything of use to mankind from electricity, did not hesitate to foresee vast uses for it. Had he been born 200 years later his fertile imagination could have taken up the challange that today's accomplishments present to us. Direct conversion of the energy of nuclear fission into electrical energy would surely have been one of his concerns. He may have been weak in imagining the extreme complexity of the electrical controls and devices used today in handling these infinite wells of energy, but he would have been among the first to foresee the brave new world which such possibilities presented. Had he been familiar with radio he would perhaps have dreamed of a sphere of electrical energy enveloping the world, supplied by solar plants at the equator, boosted by nuclear-fission generators at the poles, and tapped for use by mankind anywhere. How he would have handled inductive co-ordination with broadcasting and communication is impossible to say.

However, considering that most engineers possess Ben Franklin's earthy and human qualities, if not his extreme imaginative ability, any electrical engineer today can let his imagination conjure up a picture of his own home within a few years. It will be complex and complicated, to be sure. The component parts of it—solar batteries, heat pumps, weather conditioning, skillful illumination, refrigeration and cooling devices, cleaning, entertainment, labor saving and chore-doing equipment, comfort producing gadgets—are all ready for use. There remains only the problem of operating them.

The great steel plants, the huge communication centers, and the tremendous power stations each have their control rooms where a myriad of electronic devices provide a degree of automation which relieves the operating personnel of much tension and worry. Why not the home?

Imagine, if you will, a tiny room strategically located in your house. It will be the nerve center of your living and will be just big enough to hold two people and scores of instruments and switches. Imagine that tomorrow's plan is about to be set up by the usual Adam and Eve team. Susie is to wake at 7 with sentimental chamber music; Junior must be blasted out with a stirring martial air; Aunt Maggie's window must be down at 4:30 (she gets cold), and her coffee must approach boiling at exactly 6:45. At breakfast, Susie's facsimile news must be set for fashions; Junior's for the basketball scores; Mother's, for the social items. The eggs must be cooked—but perhaps fried eggs will still have to be under manual control. Mother's car must be warmed up at 9, the garage doors opened, and the snow off the drive-way; and so on until Pop's electric blanket goes on at midnight. The cat-ejector perhaps had worked just previously. The complete program is set up on a recording tape, buttons are pushed, instruments checked; thus, the next day is taken care of.

Who will be the chief operator? Who will throw the final switch? The electrical engineer can make the switchboard, but he will ask his brother in the social sciences to determine whether the little switch handle marked "His" or "Hers" locks in tomorrow's plan at today's end. Or maybe we need another Franklin.

Opportunities for Young Engineers in the Electrical Utility Industry

J. W. BENNETT
FELLOW AIEE

Past, present, and future problems facing the electrical utility industry are outlined. The author points out the challenges and opportunities which the utility field offers to the young engineer of today.

CIVILIZATION as it advances results in the ever increasing interdependence of all members of society. Among savage peoples, each individual, family, or tribe is an independent unit, self-sufficient in securing the necessities of life. In the advance towards civilization, commerce, in the form of a limited amount of barter, developed among barbarian peoples. In all of those civilizations which existed prior to our so-called Western Civilization, most, if not all, of the basic necessities of life were produced in the immediate neighborhood of the consumer. This was true even in the earlier periods of our industrial age. Commerce and its attendant transportation dealt principally with what, in those days at least, were luxury items.

The necessities of civilized life may be classified in two broad groups: materials and energy. Our transportation system takes care of the delivery of materials and makes them available wherever they are required, but can assist in the supply of energy only to the extent that it can supply the raw material in the form of fuel for energy production. An adequate supply of energy is the most essential factor in the advance of civilization, and a lack of such a supply the most serious handicap to its development.

Historic man has always been physically puny in comparison with his mental stature. From earliest historic times he has sought to multiply his individual effectiveness by utilizing the labor of other men as slaves, employing the strength of animals and by attempts to use the forces of nature through the medium of machines of various forms. All civilizations, no matter what their superstructure and values, rest on power. The civilization of ancient Greece, for example, rose to its heights mainly on the labor of human slaves.

Progress in utilizing the forces of nature and in the development and use of machines for the supply of power was painfully slow for many centuries. In the book "Toward Civilization" edited by Charles A. Beard, and published in 1930, it is stated: "Statistics which are believed to be reasonably accurate indicate that if all engines, water wheels, and beasts of burden, that is all prime movers, be counted in, about 10 million horsepower were available to the inhabitants of this country in 1849." Since the year 1850, the use of machine power in industry has increased at a rapid rate. Fig. 1, which was prepared from data supplied by Dr. Karl T. Compton in a paper entitled "Engineers" published in *Scientific American*, September 1951, shows the increase of machine power and corresponding decrease of human and animal power over a 100-year span. While machines supplied only 6 per cent of industrial power in 1850, in 1950 they supplied 84 per cent. It is expected that in a few years this figure will be increased to 96 per cent.

For many years after the introduction of the machine prime mover, steam engine, or water wheel, there were no means for transmitting power over great distances. Gears, shafts, and belts made possible the operation of production equipment within, at the most, a few hundred feet of the prime mover. Power could not be transmitted economically over distances measured in miles. Modern industry started with a definite limitation: manufacture by power had to take place adjacent to the power plant and, in general, each manufacturing establishment had to have its own power plant.

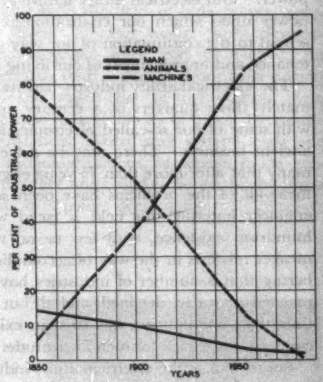


Fig. 1. Sources of power in industry

General availability of machines and general energy distribution date from the introduction of electric power near the end of the last century. We are prone to take many conveniences of modern civilization for granted. Perhaps we have never considered the fact that we would have difficulty even in the centers of civilization of getting the energy to run a sewing machine or drive a fan without electric

Full text of a conference paper presented at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955, and recommended for publication by the AIEE Committee on Management.

J. W. Bennett is with the Western Massachusetts Electric Company, Springfield, Mass.

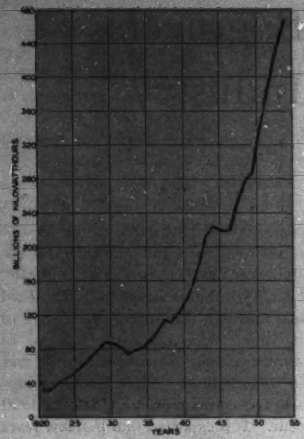


Fig. 2. Electric energy output

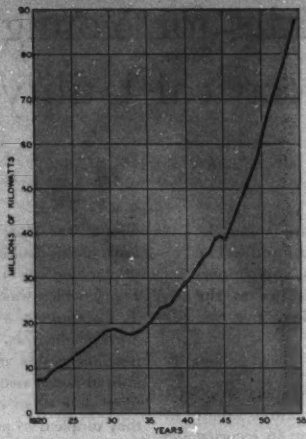


Fig. 3. Total noncoincident peak load

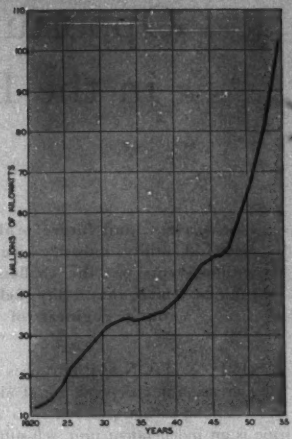


Fig. 4. Installed generating capacity

power. Our electrical utility industry, the supplier of that power upon which our civilization rests, is therefore essential to the continuation of our way of life and the maintenance and improvement of our living standards.

The electrical utility industry had its beginning approximately three quarters of a century ago. In comparison with some of our so-called electronics industries, this is an ancient business. There may be a feeling on the part of many that after more than 75 years of growth and development all of the problems have been solved, and that an engineer entering this field is faced with a routine and humdrum existence, with few or no real challenges and meager rewards in the way of accomplishments. Remembering that a number of industries have been established, reached maturity, declined, and all but disappeared in less time than our industry has been in existence, perhaps we can see some excuse for such an attitude.

Let us look at this electrical utility industry for a few moments, review its past growth, see where it stands now and, most important, where it appears to be going in the future. Fig. 2 shows the total energy, in billions of kilowatt-hours (kwhr) generated by electric utilities in the United States, by years, for the period 1920 to 1954, inclusive. It is interesting to note that the output in 1954 was approximately 12 times that in 1920. Fig. 3 illustrates the sum of peak loads on our American utility systems, by years, for this same 1920–1954 period. We observe that the 1954 peak was more than 10 times that carried in 1920. Installed generating capacity (nameplate rating) on the systems of electrical utilities in the United States in 1954 was 8 times that of 1920. The growth of installed capacity by years is indicated in Fig. 4. It would be difficult, if not impossible, to find another industry in this or any other country that can show such a rapid and sustained growth, with corresponding stability, over a comparable period.

Along with our rapidly increasing output and improved service to more people, we have made substantial improvements in efficiency of operation. One of the more interesting and, perhaps, spectacular of these is the increase in kwhr generated per ton of fuel consumed in our steam-electric generating stations. The average kwhr produced per ton of fuel burned, by years, for the period 1926 to 1954 is plotted in Fig. 5.

The past, however interesting and filled with progress and accomplishments as it has been, is but a prologue to the future. The most interesting developments, greatest challenges, and most rewarding experiences are still to come.

The electric light and power industry is basically an engineering operation. This was true in the past, is true now, and because of its technical nature always will be true in the future. Other activities, such as financing, sales activities, public relations, accounting, and legal phases, are all based on its engineering characteristics. It is essential, therefore, always to have top quality engineering leadership, if the industry is to continue to make progress. It is necessary to have engineers who are young in their viewpoint on, impartial in their approach to, and accurate in their interpretation of the problems encountered. Because of the relatively high plant investment per individual employed, it is essential that the electric light and power engineer keep the economics of every part of the system in mind at all times, and that he, perhaps more than the engineer employed in other types of industry, be able to "do that well with one dollar which any bungler can do with two dollars after a fashion."

What are some of the problems, challenges, and opportunities that are before us at present and will be in the years to come? One of the basic problems is that of over-all growth of load as expressed in total energy generated. Fig. 6 shows the increase in output by years from 1920 to 1954 and some forecasts for the next 20 years to 1975. The forecasted loads shown are by no means the most optimistic

that have been developed and published over the past few years but are, on the contrary, on the conservative side. It does not require a great deal of imagination to visualize the importance of the task of merely providing the necessary generating capacity to handle loads of the magnitude expected in the near future. And it should be remembered that this is only part of the problem. Fig. 7 shows what the electrical utility industry has done since 1946 in the addition of new generating capacity. From this picture we can visualize, to some extent, what the requirements for the immediate future will be in this phase of the industry.

Let us look briefly at some of the components of the overall problem which utility engineers must solve in the near future, at some of the research and development needed, and at the opportunities for engineers in the industry.

POWER GENERATION

IT IS ESTIMATED by a number of reliable sources that the energy output of the electrical utilities in the United States will increase over the next 20 years somewhat as shown in Fig. 6. This indicates that our 1960 output will be approximately 700 billion kwhr or 1.5 times the 1954 total generation, and that by 1970 it will have increased to 2.4 times the 1954 figure. Peak loads on our systems will increase proportionately to the energy output and preparations must be made to carry these increased loads and to supply all demands for energy. Not only must we be prepared to carry the vastly increased loads expected in the future, but we must plan at the same time to reduce plant costs and increase efficiency of operation. Specifically in the field of power generation, the following points must be considered:

1. Progress must be continued in increasing our operating efficiency and in reducing unit investment costs. To continue this progress will require ever greater effort, more knowledge of the problems involved, and greater ingenuity.

2. The application of automatic combustion, feed water, and temperature controls on large steam generators has been standard for a number of years and has, in a sense, made the modern steam generating station an automatic factory. Centralized control to improve plant operation and reduce the number of attendants has been almost universally adopted. This type of control must be continued and improved in the future.

3. Efficiency in both design and operation must be improved without increasing unit investment costs. In fact we must work toward reductions in future relative costs.

4. Other sources of power, such as power from nuclear fission, must be studied, evaluated, and assigned their proper place in future plans for expansion of generating facilities.

While the field of power generation is an interesting one and the statistics in connection with it are rather spectacular, it is only part of the electrical utility system. More than one half of the total electrical utility investment is in facilities for transmission and distribution of electrical energy. Load growth and system development present many problems in both of these fields.

POWER TRANSMISSION

INCREASING PROBLEMS in the field of bulk power transmission must be faced. Greater loads, rapid development of urban and suburban areas, and the necessity for locating new generating sources further from high density load areas require the construction of high-voltage, high-capacity lines to transmit large blocks of power over comparatively short distances. Increasing system loads and the necessity, for economic reasons, of concentrating generating capacity in larger units, makes necessary the transmission of large blocks of power over considerable distances to reach load centers.

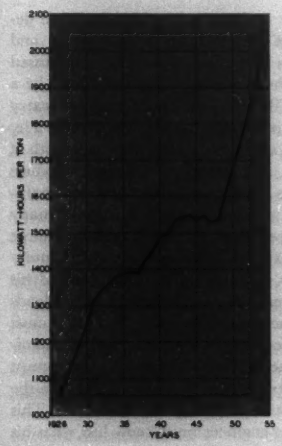


Fig. 5. Average kwhr per ton of fuel used for electric generation

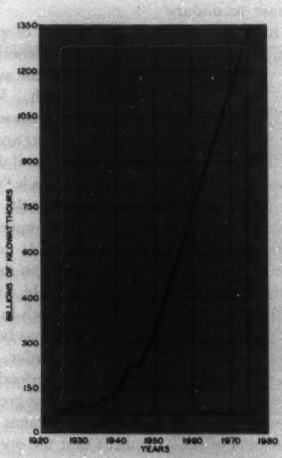


Fig. 6. Generation through 1954, with estimated growth through 1975

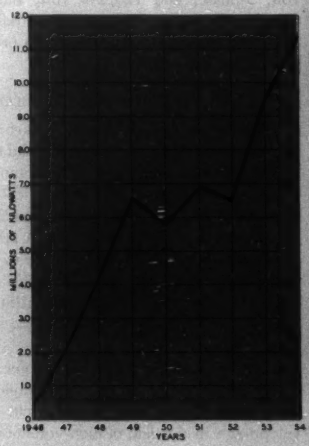


Fig. 7. Total Power generating capacity added

It has been necessary in many cases to superimpose lines of high voltage on existing transmission systems, lines of 220 to 345 kv, for example, on existing 115- to 138-kv systems. In urban areas, increased use of cable at voltages of 120 to 230 kv will be necessary in the future.

These high-voltage, high-capacity lines must be designed for maximum reliability and continuity of operation. Line and system protection must be the best and most reliable that can be obtained. The success of our bulk power systems will require the use of numerous operational control facilities such as load and frequency control, and the utilization of high frequency equipment for system protection, metering, and communication.

DISTRIBUTION

In the power distribution field, the challenges, although perhaps not as spectacular as those in the field of generation and of high-voltage transmission, are in some cases even more difficult to meet successfully. Increasing concentrations of load on the distribution system, and increased load densities make the problem of getting the energy supply from the transmission substation to the ultimate consumer ever more difficult.

Many companies are finding it necessary to use higher primary voltages than were generally accepted in the past. In a number of cases, voltages which until recently were considered only for subtransmission are being utilized for distribution, and this trend will continue at an accelerated rate in the future. Use of higher distribution voltages will, if it is to be economical, mean the concentration of greater loads and, therefore, the supplying of larger areas by a single feeder and a single substation. It is essential that these stations and feeders be designed for the utmost in reliability and be maintained and operated so as to supply an acceptable quality of service.

More concentrated loads, particularly in the heavy commercial areas, are rapidly making our standard 120/208 volt, 3-phase, and 120/240 volt, single-phase secondary distribution systems inadequate. Studies of higher secondary distribution voltages, already in progress, must be continued and expanded in the future.

RESEARCH AND DEVELOPMENT

The continual advance of the art requires constant research in various fields. It is essential that utility engineers follow research done by outside organizations in order to avoid the development of impractical designs. Extensive research is needed to determine fundamental phenomena and to solve problems of detail. A large amount of direct research by utilities has been made in the past and is now in progress. Utilities have also paid for extensive research on the part of manufacturers of utility equipment in the development cost included in the price of equipment purchased.

There have been many developments made by utility engineers as the result of both individual company-sponsored and group-sponsored research. These include developments in the field of high-voltage transmission of large blocks of power, protective relays and related devices, the heat pump for year-round air conditioning, and developments in various structural and hydraulic fields. At the present time certain utilities are engaged in work connected with supercritical steam pressures for use in steam-electric stations in the future.

PLANNING FOR THE FUTURE

The basic task of the electrical utility industry is to serve people. The utility must meet their present requirements and in the process earn a sufficient amount to attract the necessary capital, at reasonable rates, for future expansion. By the very nature of its business, the industry must anticipate its loads and the demands on its facilities several years in advance. Inasmuch as the electric power industry is the most highly mechanized of all activities in the country, with an investment per individual employed of six to seven times that of the manufacturing industry as a whole, it is essential that overexpansion of facilities be avoided. Because of this relatively large investment in plant, a high utilization of facilities and a long period of usefulness are of paramount importance.

What is being done today in system design, system operation, and planning for future growth, is related to and affected by decisions made 20 or more years ago. In like manner, today's planning will affect operations and designs far in the future.

The problem of nuclear production of power and its place in the future power generation picture is now being studied. When the goal of producing atomic power on a competitive basis will be reached is, at present, a matter of conjecture. It is quite certain that it will be reached and, therefore, this source of power generation must be taken into account in future planning. It is probable that constant probing into the secrets of nature for the benefit of mankind will reveal other useful sources of energy, perhaps a practical method of obtaining usable amounts of solar energy.

SYSTEM OPERATION

The design of specific facilities, general research and development in connection with industry requirements, and planning for the systems of the future have been discussed at some length. Will the operation of these facilities be a mere robot process? Will they, when once installed, carry on of their own accord, producing the results envisioned by the planning and design engineers? The answer to both of these questions is "no." No system, no facility will produce the desired results unless it is properly operated and maintained. The operating engineer of the future faces many challenges. He must operate all the facilities in his charge so as to achieve the maximum in economy and continuity of service. He will be expected to get more out of his equipment both in efficiency and in the magnitude of loads carried than has been the case in the past. Materials must be worked harder. Lines must be loaded to their economical limits, overload capacity of all types of equipment must be utilized to a greater extent than has been the case in the past, and outages of facilities kept to a minimum. This means that the operating engineer must know just what his equipment can do and what his loads are at all times.

In addition to the problems associated with normal opera-

tion, those of maintaining and restoring service in the event of disaster must be studied and solved.

OPPORTUNITIES

No INDUSTRY offers greater opportunity for a greater variety of technical talent. Electrical, civil, and mechanical engineering are all required in the daily operation of an electrical utility. In the search for increased efficiency of operation, improved system protection, and better use of facilities, there are numerous calls for the services of chemists, television specialists, and specialists in the fields of communication and high-frequency engineering. As we get further into the study of the economics of atomic power, there will be more opportunities for specialists in that particular field.

The electrical utility industry is unique in the free interchange of knowledge, experience, and ideas among the various companies. The developments, progress, troubles, and experiences of one company are made freely available to others in the industry either by direct interchange between companies or through group activities in various industry associations. This free interchange of information has been and continues to be an important factor in the rapid development of the industry. In addition, it offers to the individual engineer an opportunity to broaden his knowledge and, in effect, increase his fund of experience by giving him direct access to the problems, experiences, and accumulated knowledge of the entire industry.

History shows that in our industry, perhaps more than in most others, the industry leaders have worked their way up their company's ladders. A recent count of the general officers in a number of the larger utilities in the United States indicated that some 38 per cent of these were engineers or had engineering training.

SUMMARY

THE ELECTRICAL UTILITY INDUSTRY is dynamic, with boundless opportunity and capacity for growth. Advancement and growth cannot be achieved by merely doing more of the same. What was done yesterday will not suffice for tomorrow. Past practices must be re-examined and re-evaluated. A fresh approach to present and future problems must be made. Present materials must be worked harder, and new ones that are stronger and better must be developed.

Young engineers entering the industry will find a full measure of glamor in supervoltages, electronic relays, high and ever higher steam pressures and temperatures, and new applications of all types of control and supervisory equipment. But of far greater importance is the fact that they will face the challenge of an almost infinite variety of problems. The engineer who becomes a part of a power company organization must have the breadth of vision and the capability to make his engineering accomplish the broad purpose of the industry.

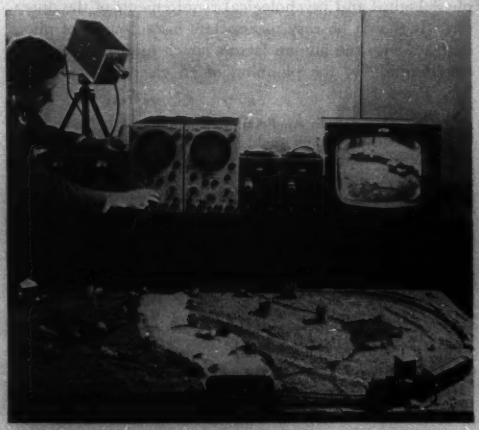
There are still partly charted and uncharted areas and major problems ahead in all branches of the industry as the demand for electric energy continues to grow. The ambitious and energetic man can be sure that he will be kept busy trying to keep up with his responsibilities. He will join a group of skilled engineers, men who have spent most of their working life in the industry, and who know the pride and satisfaction that comes from accomplishment.

To exploit opportunity has always been difficult; to raise the standard of living of people and to make important contributions to the well-being of many are never easy. Were it otherwise, the challenge and the opportunity would not be so great and men with lesser qualifications could do the job.

Electronic Instruments Record and Display Minute Strains

Use of electronic instruments to record and display automatically minute strains and displacements in materials undergoing a manufacturing or handling process, as demonstrated through a novel model-railroad setup, was recently exhibited by Allen B. Du Mont Laboratories, Inc., Clifton, N. J. The demonstration also indicated how industrial processes may be monitored and remotely controlled by closed-circuit television.

The strain and displacement are picked up by gauges under the trestles, which the train crosses repeatedly. The information is fed to strain-gauge controls (left) and differential transformer controls (left of TV monitor). The output of these instruments is connected to two cathode-ray oscillographs (center), where the strain and displacement appear as wave forms. The remote control feature is demonstrated by a Du Mont "Tel-Eye" camera which televises the railroad setup and relays the picture by cable to the monitor (left). In an actual demonstration, strain and displacement is shown on a large-screen indicator.



Factoring the Human Equation into Electrical Testing

C. R. DeREAMER H. E. VANN
ASSOCIATE MEMBER AIEE

Many accidents are actually "built into" test equipment through failure to take the human element into consideration. Methods are presented for the elimination of a large percentage of these accidents.

IT IS OFTEN STATED that a high percentage of industrial accidents, including electrical testing accidents, are due to unsafe acts. Reams of data and reports are available which classify accidents as having resulted from poor techniques, lack of judgment, recklessness, and even downright stupidity. Thus, the conclusion is reached that all that needs to be done is to eliminate these unsafe acts and accidents will stop.

One of the major objectives of this article is to demonstrate that these so-called unsafe acts in the electrical testing field may not be the fault of the electrical tester or the test engineer. Evidence exists which indicates that many so-called operator errors have been touched off by faulty design of the test equipment, poor working conditions, operating practices that expose the tester to hazards, or lack of standardization and identification which so confuses the operator that he is psychologically trapped into making mistakes. In effect, potential accidents have been built into some test setups because the design engineer or methods man has not included the human factor, although his handling of the functional problem was adequate.

Wesley Price gives a prize example of what can happen when engineers fail to relate mechanical design to the physiological and psychological requirements of the operator. It should be easy to associate his account* of pilots' mistakes with the human factors which must be taken into consideration in the planning of an electrical test setup. Mr. Price relates:

> "They [the Army Air Force] had an epidemic of landing-gear mishaps. Planes would grease safely onto the runway; then, while taxiing, the wheels would fold up and let the aircraft bang its belly on the concrete. The trouble was that pilots were, by mistake, flipping the switch that retracted the landing gear. They meant to hit another switch to retract their wing flaps. Confusion of these two controls alone crumpled 303 Air Force planes in a single year, 1943.
>
> "Were these pilots stupid? It seemed so, until experts of the AAF Flying-Safety Division studied flap and gear toggle switches. They often looked alike, felt alike, and—pity the poor pilots—were only inches apart. Mix-ups were inevitable. The flap-gear confusion had been virtually built into the airplanes. The AAF ordered the twin switches separated by at least two feet. The effect was magical. Overall frequency of these accidents was promptly cut in half.
>
> "But it was still not impossible to retract the gear inadvertently, as a few absent-minded pilots proved from time to time. The final step was installation of an automatic safety lock. You could move the gear control to 'Up,' but the wheels would refuse to fold if they were on the ground. The device is standard equipment now on modern military planes and airliners. It 'remembers' when pilots forget.
>
> "A rare exception was the taxiing accident at Shannon Airport in Eire last September. The main gear of a Constellation tucked up and let the ship fall heavily to the runway, supported only by the nose wheel and tail. Nobody was hurt, but a costly airplane was bent beyond repair. The copilot, mistaking the gear lever for the flap lever, had yanked it so forcibly that a pin-locking slot in the safety mechanism gave way. Engineers hastened to make the safety lock muscle-proof.
>
> "The copilot, it transpired, had had a lot of time in Douglas DC-4's, not so much in Constellations. The gear handle in a Connie is about where the flap handle is in a DC-4. Old habit asserted itself. The copilot reached down and committed a pilot error. Or did he? It can be argued that he fell victim to the industry's apparent inability to standardize cockpit layouts."

Any discussion of electrical safety should start from the basic premise that engineering skill for controlling electricity and an exact knowledge of the effects of electricity on the human body are available. Therefore, steps can be taken to design electrical test setups that will isolate the tester from live electrical circuits or so limit the current values that the contact will not be harmful. Experience has proved that it is not enough to design the test setup just to satisfy the functional requirements of the operation. It is also necessary that the engineer include the human equation in his set of formulae, standards, and specifications. If this approach is carried out in practice, fewer accidents will result, training time will be reduced, and costly changes in the test setup after it has been put into use will be eliminated. In the design of electrical test equipment and the development of test methods, certain considerations must be made for adequate integration of the human factors into the functional requirements of the test.

STANDARDIZATION

THE NECESSITY of providing maximum safety in electrical testing has motivated the General Electric Company to capitalize on experience from widely diversified sources and to establish a set of safety standards for electrical testing operations.

Essentially full text of a conference paper presented at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955, at a session sponsored by the AIEE Committee on Safety.

C. R. DeReamer and H. E. Vann are with the General Electric Company, New York, N. Y.

*Why Pilots Make Mistakes, Wesley Price. *The Saturday Evening Post*, April 19, 1947, pp. 18–19.

A "Testing Safety Rule Book" has been maintained over a 16-year period to aid the test designer and methods man in integrating the human and functional requirements into the design of electrical test setups and to assist the first level supervisor in establishing practical safety requirements for electrical testing operations.

The standards are based on years of experience in electrical testing and recognition of the basic principle that Safety Standards must implement and not impede production. The rules are hinged upon two broad objectives, which are:

1. To isolate electrical hazards with interlocked enclosures that will automatically interrupt power when a hazard is present.
2. To design characteristics into the test equipment and safety devices that will automatically remove power and eliminate the hazard in case of an equipment failure or malfunction. These are called "fail-safe" characteristics.

The influence of these two broad objectives can best be illustrated by reviewing some basic standards and the sequence in which they may be developed.

The first and most logical step in electrical testing safety is to build an enclosure around the equipment being tested that will isolate the hazard inside the enclosure so contact with a "live" electrical part cannot be made from outside the enclosure. This might be sufficient if the operator would always follow the proper procedure and remove power before entering the enclosure, but experience indicates that additional consideration is necessary. The next step is to wire all primary power to the enclosure through a visible disconnecting device. The disconnecting device would be arranged so that it is apparent from visual observation whether the circuit is open or closed.

As a check on the disconnecting device, a single red light could be added to the enclosure to indicate when power was on and a hazard existed inside the enclosure. However, the operator's awareness soon becomes dulled to a single red light, so to correct this condition a flashing red light could be substituted. But what happens if the single light burns out? Obviously the operator could be trapped into thinking power was off. By modifying the setup to include two flashing red lights in parallel, this condition can be eliminated. These lights can be so installed that any malfunction of equipment or sticking of a contactor or breaker would keep the lights flashing and denote the presence of a hazard. However, unless a carefully supervised maintenance procedure for replacing burned-out lights is established and followed, the two lights would be little better than a single light.

The use of a test enclosure and flashing red lights to indicate a hazard inside the enclosure is still not sufficient because workers are sometimes likely to forget to follow normal routine. Under such circumstances they could enter the enclosure without first removing power. The next step would be to add an electrical interlock across each enclosure entrance, so the enclosure could not be entered without breaking the circuit and removing power. With this arrangement the tester automatically eliminates the hazard when he enters the test enclosure.

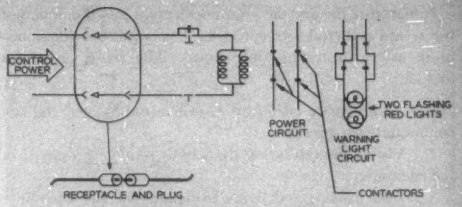


Fig. 1. Typical interlock circuit

Fig. 2. Test table with interlocked meter and instrument enclosures. Circuit is automatically broken when meter terminals are exposed

If an interlock is to be used as a safety device, steps must be taken to assure that failure of the device to function would not jeopardize the safety of personnel depending upon the device. To fulfill this requirement, performance standards could be established for the interlock and its control circuits. These standards would include:

1. Fail-safe features, such that any failure of the interlock mechanism, loss of power, short circuit or malfunction of equipment would cause the circuit to be interrupted.
2. A "wired-through" type of control circuit located in the primary power circuit.
3. An arrangement which makes it impractical to circumvent the interlock.

An interlock circuit meeting these requirements is shown Fig. 1. It should be pointed out that spring-activated or shorting-type interlocks do not meet the requirements of a safety interlock.

Isolating the hazards inside an interlocked enclosure will not eliminate electrical hazards unless steps are taken to prevent hazards from being extended outside the enclosure through meter leads and control wiring.

The next step would be to establish standards for auxiliary equipment used in conjunction with the test setup. Meters, gauges, and exposed "live" parts should be protected with the same principles that apply to the equipment under test. A simple method for doing this shown in Fig. 2.

Integrating the so-called human element into the design of test setups and establishing test standards will provide maximum safety in testing operations. The basic principles include:

1. An adequate enclosure to isolate the hazard and accommodate the products.
2. Visible disconnecting devices to remove power from the enclosure.
3. Two flashing red lights to denote the presence of a hazard.
4. Protective interlocks that "remember" when humans forget.
5. Confining all conductors leaving the enclosure so that no hazard is brought out by auxiliary equipment or measuring devices.

Some of the different types of interlocked enclosures used by the General Electric Company to test a wide variety of products ranging in size from turbine generators to toasters are shown in Figs. 3, 4, 5, and 6. Each of these enclosures meets the safety standards discussed in the preceding paragraphs, even though details vary to accommodate the product being tested.

Fig. 3. Table top test enclosure used for testing small light equipment

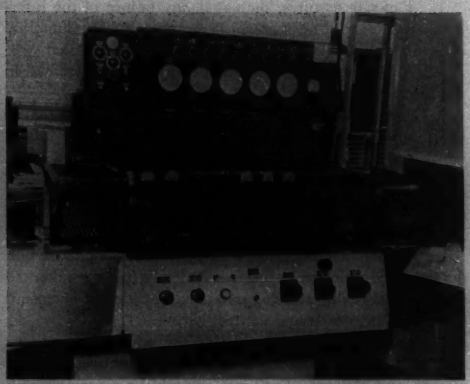


Fig. 4. Fast conveyer line test enclosure used for testing small equipment on a fast moving conveyer line

IDENTIFICATION

IDENTIFICATION OF CONTROLS, test enclosures, and other items where knowledge is essential for operation and safety, should be considered in the test setup. It is treated separately here to emphasize its value in preventing operators from becoming confused and making mistakes in judgment.

Numerous accidents have resulted from improper power plugging. Investigation of these accidents generally reveals that proper identification on the plug board may have prevented the accident. This can be illustrated by relating a typical accident that occurred during a plugging operation. A tester attempting to remove power from a test setup received electrical flash burns when he removed two plugs from the board, and they accidentally touched. The board was arranged so that power could be transferred by plugging cables from receptacles connected to the power source through another set of receptacles to the test setup. The board was not marked, and the tester, through a mistake in judgment, pulled out the wrong leads and short-circuited the power supply when the ends of the two leads touched. A mistake in judgment, yes—but adequate identification of circuits on the board may have prevented the accident.

Frequently, lack of identification of controls will cause the operator to make a mistake and pull the wrong switch or open the wrong breaker. It takes little imagination to realize the seriousness of this when in case of emergency an operator does not know which switch to open or, for example, he mistakenly removes the field power for a d-c motor while intending to take the unit from the line be- because of trouble during the test.

The reaction of an operator during an emergency or when performing repetitive operations should be anticipated and allowances factored into the location and identification of controls to minimize mistake in judgment.

Color coding can be used effectively for ready identification, such as painting controls blue and stop buttons red.

Schematic diagrams can be provided on equipment where such knowledge is helpful to safe operation of the equipment. Adequate identification of controls and proper use of signs are good investments providing that the use of colors and signs are standardized and meaningful.

PROPER OPERATING SEQUENCE

EVEN THOUGH human considerations are factored into the design and installation of electrical equipment, it may be to no avail unless steps are taken to assure proper sequence of operation. This can be illustrated by a knife switch and breaker combination in series in the same power line. The breaker is provided to interrupt the circuit, and the switch is used to isolate or change the circuit. This is adequate if the proper sequence is followed and the breaker is opened first. Past records give conclusive evidence that unless steps

are taken to assure proper sequence of operation, operators will sometimes open the switch first. When a high-voltage power circuit is interrupted with a knife switch the results can be disastrous. It is a worthwhile investment to interlock the knife switch mechanically to the "hold in" coil on the breaker so that the knife switch cannot be opened with the breaker in the closed position.

This approach will necessitate proper sequence of operation; however, in some cases it may not be practical, and an alternate method is needed. The alternate method be the automatic elimination of the hazard in case of improper sequence, such as the use of an electrical interlock on the test enclosure.

The American Standards Association (ASA) code for the design of a 3-prong plug is a good example of the steps that can be taken to assure proper sequence of operation. Users of portable electrical tools with a 2-prong plug and ground clip are instructed to connect the ground clip first, then insert the plug. This safety precaution is frequently violated and the sequence reversed or the ground connection not made at all. Use of a 3-prong ASA type plug, with the ground prong longer than the two current-carrying leads, will assure that the ground connection is made first and proper procedures followed.

Wherever possible the designer should lay out the test setup and select equipment that will assure proper operating sequence. Where this is not possible, methods should be used that will minimize the hazard when proper sequence is not followed. For example, it is possible and quite probable that a lead connecting power from a plug board to a test may be disconnected in such a manner that one exposed end may be electrically hot. The shock hazard can be reduced by polarizing the plug so that only the male end will fit the plug board (source of power) and the female connected to the test. In case the cable is removed from the test equipment without disconnecting power, then the "live" part will be protected.

FAILURE OF EQUIPMENT

THE USER should be aware of the possibility of equipment failure, even though the functional specification for equipment is met, and he should take precautions to provide adequate equipment and personnel protection in the event of such failure. Past experience has dictated that at least the following protection be provided for electrical equipment:

1. Overcurrent devices that will limit the current to a value that can be safely carried by the test equipment and the product being tested.
2. Grounding noncurrent-carrying parts to provide a path for possible fault currents.
3. Automatic circuit-interrupting devices that will disconnect power in case of a failure, such as fuses, circuit breakers, or contactors.
4. Undervoltage devices, where needed, such as on the d-c field on a motor.

It is necessary to take an additional step in cases where there is the possibility that an equipment failure will create a hazard, such as the explosion of a circuit breaker during an overcurrent test. In this case, additional provisions are required to confine the potential hazard.

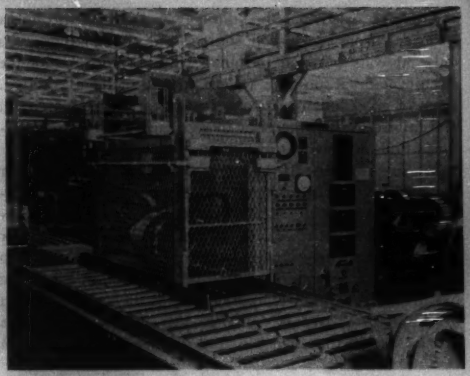


Fig. 5. Slow conveyer line test enclosure used for testing heavy equipment on a slow moving or manual conveyer

Fig. 6. Walk-in type test enclosure used for testing large heavy equipment

CIRCUMVENTING SAFETY DEVICES

AN ANALYSIS of electric shock cases indicates that in numerous instances where it is normal practice to provide interlocked enclosures and standards, many accidents are the result of the operator circumventing the safety device. The principal reasons for this are:

1. *Poor judgment.* A specific case in point occurred when a low-voltage test setup for testing breakers was modified for a special test. The voltage in the original test was approximately 8 volts and was supplied from a fixed source. In order to accommodate a larger current for a special test, the circuit was changed to obtain 30 volts. A tester made accidental contact with the exposed part of the circuit and was electrocuted. The investigation of the

accident revealed that the voltage was obtained through a "Variac" from a 440-volt source, and though there was only 30 volts between terminals, the modification of the circuit made it possible to obtain 440 volts to ground. Lack of good judgment in the modification of this circuit and failure of the supervisor to recognize the hazard effectively built an accident into the test equipment.

2. *Inconvenience.* If the safety device is inconvenient for the operator to use, the natural tendency will be to circumvent the device. A highly repetitive operation that requires the tester to activate an interlock mechanically for each operation may create a desire on the tester's part to tie the safety device down, if he is not keenly aware of the hazards. In making temporary setups, it is a temptation to eliminate or bypass such items as electrical interlocks because of the time, trouble, and expense of putting them into the circuit.

3. *Bottlenecks.* If the enclosure or interlock causes a bottleneck in the production line, it will invite circumventing existing equipment or eliminating the restrictive safety device. A careful study of the method of testing will, in many cases, show that there is a better method of performing the test that is more compatible with the manufacturing operation. (For example, on some high potential testing operations it is possible to limit the test current to less than 5 milliamperes. Currents less than 5 milliamperes are not harmful to the body; safety devices are not needed.) The designer has an obligation to study these factors and take them into consideration in the layout of the test setup. This is essential if we are to maintain a set of safety standards that will be compatible with the rapidly changing manufacturing requirements.

FELLOW EMPLOYEES

THE FACT that another employee could unknowingly subject the tester to a hazard should also be factored into the safety standards. To prevent a fellow employee from energizing a circuit that would subject personnel working on the equipment to injury, a tag-out procedure should be established. The General Electric Company uses a circular red tag for locking out electrical circuits that, if operated, would subject personnel to injury. It is hung on the primary disconnecting device that controls the power to the equipment. Instructions on the tag prohibit the operation of the switch until the tag is removed by the person who signed the tag.

Establishing a definite procedure to clear electrical circuits before switching power may prevent a person from unknowingly causing an accident. The procedure should require that a check list be established to notify all parties concerned of the action to be taken and the safety precautions necessary to eliminate the hazards.

A procedure should be established to prohibit a person from working alone on a hazardous test. This will assure that a person involved in an accident will have a better chance of survival. A complete set of operating procedures for each test is needed so that all people involved will be aware of the hazards and know the safe procedure to follow to prevent exposing themselves to hazards or jeopardizing the safety of fellow employees.

CONCLUSION

THERE IS NO EXCUSE for fatal electrical accidents in electrical testing operations. The hazards of electricity and its effects on the human body are known, and they can be controlled.

Analyzing the environment in which the tester operates and his reaction to factors in this environment will provide the vital information needed to satisfy the human requirements. Integrating these human requirements with the functional requirements of the electrical testing operation will provide an equation that will eliminate electrical shock as a source of industrial fatalities.

The answer to this equation is to establish for each test set up:

1. A set of operating procedures that would, if followed, provide adequate safety.
2. A means of identifying and isolating electrical hazards so that contact cannot be made with a "live" part.
3. Safety devices that will remember when people forget and automatically removed power when a hazard is exposed.
4. Fail safe characteristics of the equipment and safety devices so that failure or malfunction will automatically remove power and eliminate the hazard.

Stringing Power Line Conductors

A machine for stringing overhead power line conductors under controlled tension has been announced by the Petersen Engineering Company, Manufacturers, of Santa Clara, Calif. The model *6000-WS*, pictured, takes all

conductor sizes up to and including $1^{1}/_{8}$ inch diameter. It accommodates all sizes and types of reels currently being provided as standard from the wire mills.

The braking takes place over the double bull wheels of cast aluminum alloy, which are neoprene lined to prevent conductor damage and slippage. One reel tender can easily control the brakes on one unit holding two reels, or using two units close together, can string up to four conductors simultaneously.

Efficiency of Grounding Grids with Nonuniform Soil

J. ZABORSZKY
MEMBER AIEE

STUDIES DEVOTED TO PREDETERMINATION of ground resistance on the basis of geometric dimensions and ground resistivity generally assume that the resistivity of the soil is uniform. While this assumption is frequently justified in view of the usually meager knowledge of the actual ground resistivity distribution and the mathematical difficulties caused by any nonuniformity of the ground resistivity, it also can be misleading under certain conditions.

A case in point is a ground electrode site which contains a shallow but moist topsoil layer of fairly good conductivity overlaying poorly conducting rock. On such a site, grounding grids situated in the soil layer would normally be used.

Highly refined techniques have been developed for calculating the ground resistance of grounding grids in uniform soil. However, an attempt to apply these to nonuniform soil can be unsatisfactory since conditions change markedly if the nonuniformity is substantial.

The study of a special type of grounding grid is developed here for nonuniform conditions with the expectation of obtaining at least approximately quantitative indications of what might be expected on grids of more conventional design.

The type of grid selected for mathematical expediency consists of concentric rings of round thin conductors buried in the uniform topsoil layer, which is assumed to overlay a higher resistivity but also uniform rock layer. Conventional grounding grids usually consist of a rectangular mesh; such a structure is characterized by a uniform average density of conductor (feet of conductor per square feet of area). In order to make the information obtained in this study approximately applicable to such conventional grids, uniform average density of conductor material was maintained throughout the proposed concentric grid.

When several concentric rings are connected to form a single grounding grid, the distribution of the ground current between the individual rings and the ground resistance of the entire grid can be calculated by the use of self- and mutual-resistances.

Shown in Fig. 1 is the variation of the total ground resistance of a grid of the studied type with the conductivity ratio λ_2/λ_1 of the two layers in the soil. Ratio of outside grid radius to depth of top layer is 55; its ratio to conductor diameter is 5,000. The ground resistance is expressed in per cents of the ground resistance that would be obtained if all the conductor length in the grid were used in one single ring electrode of appropriate diameter. It can be observed from this diagram that the ground resistance of the grid will be about twice as large for the grid studied and, interestingly, the extent of the nonuniformity of the conductances has only limited effect on this ratio.

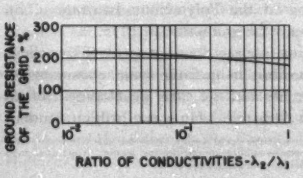


Fig. 1. Ground resistance of grid in per cent of ground resistance of single ring, using the same length and diameter conductor as the grid

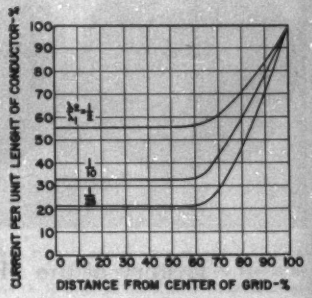


Fig. 2. Current discharge into ground per unit length of conductor as function of the distance from center of grid, using same system as in Fig. 1

Shown in Fig. 2 is the variation of the current discharged from one unit length of conductor as function of the distance from the center of the grid. It may be observed that this current density, which is a measure of the efficiency of the individual sections within the grid, takes on a high value only on the periphery of the grid and drops rapidly toward the center of the grid, even if the difference in the conductivity is relatively moderate, such as $\lambda_2/\lambda_1 = 1/2$.

Even relatively moderate vertical variations of the ground resistivity have extensive effects on the efficiency and ground resistance of grounding grids. Such variations should be a major consideration in predetermining ground resistances, and the results of this study are believed to give some aid toward that end.

It may be seen that an underlying higher resistivity layer in the soil renders the inner portion of grounding grids increasingly ineffective, with increasing nonuniformity of soil conductivities.

It is more economical to use the conductor material spread out on as large a periphery as possible; the periphery rather than the area of the grounding electrode determines the ground resistance.

While the numerical results expressed in the figures apply strictly only for the special type of grid that was studied, it is expected that they give good approximations also for square-mesh grids, using same conductor length and diameter if the area is not very elongated.

Digest of paper 55-713, "Efficiency of Grounding Grids with Nonuniform Soil," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3-7, 1955. Published in AIEE *Power Apparatus and Systems*, December 1955, pp. 1230-3.

J. Zaborszky is with Washington University, St. Louis, Mo.

Leonid A. Umansky 1955 Edison Medalist

". . . for his outstanding contribution to the electrification of industry . . . and for his inspiration, leadership, and teaching of men in this work."

History of the Medal

E. P. YERKES
FELLOW AIEE

THIS OCCASION marks the 45th presentation of the Edison Medal, which is awarded annually ". . . for meritorious achievement in electrical science or electrical engineering or the electrical arts." On these 45 occasions, achievement in all branches of our profession in which Thomas Alva Edison labored with such distinction have been recognized. So, also, have virtually all of its other branches, including those which have arisen since Mr. Edison's time. Today's award, in going to Leonid Alexander Umansky ". . . for his outstanding contribution to the electrification of industry through the application of electrical machines, devices, and systems to automatic process machinery; and for his inspiration, leadership, and teaching of men in this work," is thoroughly in tune with both the spirit and deed of these previous awards.

Selection of the Medalist is the responsibility of the Edison Medal Committee of the American Institute of Electrical Engineers. The Committee of 21 members consists of two parts—the first comprising 6 members of the Board of Directors having 3 members elected, by secret ballot of the Board each year, for a 2-year term; and the second part comprising 15 members from the general membership of the Institute having 3 appointed each year by the President, for a term of 5 years. By constituting the Committee in this manner, continuity in its operations and in its point of view is preserved, and experience in the conduct of its duties is carried over from year to year. Candidates for the Medal are proposed by the Committee, by groups of Institute members such as the Sections, or by individual members. The Committee discusses the candidates thoroughly and confidentially in a committee meeting and by secret ballot arrives at the selection of a single candidate. As it is not likely that the complete Committee has attended the meeting, the entire Committee membership is subsequently polled by letter ballot, so that the candidate chosen is the selection of the entire Committee, not just those present at the meeting.

The culmination of the Committee's work as portrayed in this ceremony is a very pleasant task, but the preliminary work, that which precedes the final selection, is most difficult. It is both pleasant and fairly easy to discover men whose achievements qualify them for the Edison Medal, but to search out and choose one among them supremely qualified is most difficult. The Committee is glad to be able to say, as have its predecessors, that it is proud of its work, and that the present Medalist, in joining the distinguished list of former Medalists, confers still further distinction upon that group.

The Medal Recipient

F. M. ROBERTS
FELLOW AIEE

LEONID ALEXANDER UMANSKY was born in Nikolaiev, Russia, an industrial and shipbuilding town, on July 23, 1890. His father was a mechanical engineer, and some of his forebears, including a grandfather who pioneered the coal mining industry in southern Russia, were engaged in one form or another of industrial activity.

After the usual boyhood training in what we call the elementary and high schools, he enrolled as a student of electrical engineering at the Polytechnic Institute of St. Petersburg from whence he graduated in 1915.

Mr. Umansky, being modest, does not speak of his college years; but, with a little help from some classmates, a picture of his college life and the early development of his character have been gathered. He was a brilliant student

Presentation and acceptance addresses at the Edison Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956.

E. P. Yerkes is engineer of equipment, eastern area, Bell Telephone Company of Pennsylvania, Philadelphia, Pa.

F. M. Roberts is manager, systems application engineering section, Apparatus Sales Division, General Electric Company, Schenectady, N. Y.

and had the custom been in vogue in Russia at that time, he might very well have been elected by fellow students as "most likely to succeed."

Organization of a class to study English was one extra-curricular activity he inaugurated because technical publications in our language held his interest and he particularly wanted to be able to read the AIEE *Proceedings*. Today, his ability to speak English fluently and to write it well is a fine tribute to Miss Grace Spence, London, England, who taught those boys. This mastery of English has contributed in a large degree to Mr. Umansky's success in explaining and teaching his engineering.

He organized a society of electrical engineering students called "The Electrical Circle." This was not unlike the student branches of AIEE. Technical papers were presented by the students, just as is done in the AIEE today, and the "Transactions" were printed and bound in a book at the students' own expense. During the organization of this "Circle" he carried a file of the early *Proceedings* of AIEE and tossing them on the conference table remarked, "Here is our model, we should do like that."

World War I was under way when he graduated from college so that his first postgraduate activity was as a civilian employee of the Imperial Russian Artillery. He was given a two months' course in munitions manufacture and then packed off to the United States as a munitions inspector. He landed in New York December 16, 1915, and at once was assigned to the General Electric Plant (GE), Schenectady, N. Y., to inspect detonators for high explosive shells which were being manufactured there for the Russian Government.

He must have been well impressed with our workmanship at that time for, after three years of munitions inspection and following the Revolution in Russia, he applied for a job with General Electric and was accepted as a student engineer, or test man as they were called in those days. He began his career with GE on February 7, 1919, and accomplishments from that day show how he made use of the opportunities afforded him in his adopted country.

In June 1920, he was assigned to work as an "application engineer" in the GE department assigned to follow a kind of engineering which involved the systematic application of electrical apparatus in industry. This assignment was so natural and satisfactory that he has spent all of his professional life in helping to develop his kind of engineering which is recognized today as indispensable to the electrification and development of our product industries.

This is the first time that the Edison Medal has been awarded to an engineer who has distinguished himself in the field of industrial application engineering.

In 1920, much of American industry was unelectrified. However, the electrical manufacturing industry, which had gained impetus during World War I, was young, aggressive, and in the hands of capable management. It needed engineering guidance and direction to play its part in stepping up production, creating new and better jobs, and making all the astonishing and magnificent contributions which have resulted in our amazing record of industrial progress. But, before these contributions could be made application engineering had to be developed. If one man can be considered the leader in developing this new type of engineering service, Mr. Umansky is that man.

LEONID A. UMANSKY, retired engineering manager, General Electric Company, being presented with the Edison Medal by AIEE President Morris D. Hooven at the Winter General Meeting, January 30, 1956, in the Hotel Statler, New York, N. Y.

It was conceived that the application engineer should bear the same relation to his work as does an architect to the finished building. He should visualize each industrial project in its entirety—from conception to completion—and so co-ordinate all parts that a smooth functioning whole would be the result. The power generation and distribution equipment, the electrical utilization apparatus, and the production machinery all must be considered as part of the over-all system even in the application of a single product if success is to result.

Typically, Mr. Umansky was assigned to tackle one of the biggest and most formidable of all problems—the electrification of the steel industry.

A whole series of important electrification projects can be recorded as resulting from his work in the industry. He early recognized the importance to all industrial applications of adjustable speed to obtain flexibility, optimum production, and high efficiency. One of the first major contributions he made was to analyze all available adjustable speed drives—both alternating current and direct current, and provide direction as to their most profitable use. Today the original paper presented by him, in September 1924, to the Association of Iron and Steel Engineers, is still the classic treatise on a-c drives.

Pioneer in the use of synchronous motors for rolling mills; Mr. Umansky applied the first electrical equipment to flying shears. He received the Coffin Award, the highest GE award for extraordinary contribution, for his initial application of d-c motors to runout tables. He invented and patented the magnetic tensiometer when he saw the need to measure tension between the rolls of cold rolling mills. This device, in wide use today, makes possible the high speed operation of such mills. It is significant that Mr. Umansky was thinking in terms of what we today call

"automation practices" in these early days because he specified at the time that the tensiometer could be considered as a means for controlling the tension as well as measuring it.

On February 4, 1927, Mr. Umansky became a citizen of the United States.

In conjunction with T. M. Linville he conducted an investigation into the transient speed regulation of d-c motors and their findings were presented in *Electrical Engineering*, April 1935. He encouraged and stimulated use of rotating amplifiers, made the first application in the United States of power rectifiers for main roll drives, and developed a power factor control for strip mills which is still in use.

In all, Mr. Umansky has 18 patents covering his inventions, and his work is recorded in dozens of articles and papers, many of which were presented before the AIEE.

In 1940, he was put in charge of engineering for all GE industrial applications. In this capacity, he had opportunity to assess the over-all relations between electrical manufacturers and the industries and saw the need for much closer co-operation and better understanding. He felt that this could be accomplished through AIEE. He actively co-operated in the formation of the General Industry Applications Committee, of which he was first chairman, and encouraged the holding of industry conferences within AIEE, each devoted to a specific industry, such as: the Rubber Industry Conference in Akron, Ohio; Machine Tool Industry Conference in Cleveland, Ohio; and elsewhere. This work within the Institute has done much to promote better understanding between electrical engineers in all industries.

During World War II, the 400-cycle a-c power system for large aircraft was developed under Mr. Umansky's supervision. He fostered and inspired many improvements in industrial power systems practices. He encouraged the use of higher distribution voltages and higher voltage lighting, thus saving hundreds of tons of strategic materials, and the "load center system" when its associated factory assembled unit substations. These improvements enabled many new war production plants to manufacture months earlier than otherwise would have been the case.

He has continued to advocate the use of adjustable speed drives which are now essential to the adoption of automation principles in industry, and he has been one of the most enthusiastic proponents of the use of mercury-arc rectifiers for such applications as main roll drives in the steel mills and the electronic printing press drives, as well as in electrochemical processes. The multigenerator sectional paper machine drive, with its precise electronic regulator, was developed under his direction. He has encouraged and expanded the use of industrial electronics, adoption of magnetic amplifiers, process instrumentation and control, and all kinds of regulating and feedback systems.

In a slightly different field it was he who initiated the use of gas turbines for pumping gas in pipe lines, and he did much to encourage the use of gas turbines in locomotives.

Although these achievements have made him one of the outstanding engineers in our country, his greatest single contribution has been as a teacher and leader of men. He has devoted time to encourage and train young engineers, and has never missed an opportunity to provide guidance and encouragement to the younger men—both in and out of GE. He has systematized the training within the company by organizing what is called the "Umansky University," a unique institute for training application engineers.

His direct objective approach to the solution of any problems, his dry humor and his unfailing efforts to see both sides of any question have endeared Mr. Umansky to engineers.

Recently, he made a statement which is typical, and I quote:

> "Let me publicly acknowledge one debt of which I have always been conscious. I came to this country almost 40 years ago with a college education and very little else. Here, I got the opportunity to be a free man, to work in my chosen field, and to develop to the limit of my own ability. This country, and its people—including you, ladies and gentlemen—has adopted me as one of its own. And for this I am deeply grateful."

I think that our friend has repaid his adopted country to the full by his many contributions and we, too, are grateful for the opportunity which has been given to us to know and to work with this great American engineer.

Electrical Engineers in Industry

L. A. UMANSKY
FELLOW AIEE

I WOULD BE LESS THAN HUMAN if I did not feel a deep gratitude to the Institute, and its Edison Medal Committee for the high honor bestowed on me—and if I did not feel a certain amount of pride in this honor. Yet, I fully realize that, although an individual is often singled out, it is really associates amongst whom he has spent his active years, that jointly deserve the honor. These associates create the proper working atmosphere, they train or assist the individual, offer guidance and suggestions, share his work and, in short, make the man a member of the team.

Throughout my professional life, I was associated with the group of engineers whose task it has been to electrify and operate our industry. The application engineers of the electric equipment builders and, particularly, the electrical engineers in our great mining and manufacturing industries, comprise this team. My close association with them for many years, gave me a good opportunity to observe and to appreciate their great contribution to our life.

Let us consider the background of this activity. The abundant and rapidly growing use of power is the cornerstone of our high industrial productivity or—which is another way of saying—of our standard of living. The rising amount of worldly goods we have and the increased hours of leisure to enjoy them are made possible by this growing use of power. Although I do not want

L. A. Umansky, retired, engineering manager, Industrial Engineering Division, General Electric Company, Schenectady, N. Y.

to deprecate the importance of spiritual values in life, I believe that it is the material well-being which frees our spirit and intellect and permits us to become better all-round men. In 1955, our industry consumed over 300-billion kwhr, or more than 55 per cent of all electric energy used in our country. Only a generation ago, each production worker had less than 3 hp at his disposal; now he has over 10 hp. His muscle power is now amplified more than a hundredfold. His productivity, always high as compared with the rest of the world, rises at an average rate better than 3 per cent per year. Not only do we mechanize the industry, i.e., apply electricity as a motive power, but we extend at an even higher rate the use of electricity for electrochemical processes and electric furnaces. In the last 15 years alone, this annual use has jumped $5^1/_2$ times from 10- to 54-billion kwhr. From all the evidence at hand, the industrial use of power will more than double in the next 10 years.

But the use of electricity means far more than providing a mere bulk of power for industry. It permits of its easy transmission into strategic spots; of subdividing it, when needed, in multiple units, greatly simplifying the mechanical design of process machinery; of application of closely regulated adjustable-speed drives for continuous processes of unprecedented high speed; more often than not, of changing the processes themselves. Most important, electricity has made possible the application of intricate and automatic controls. Thus, it supplies the "brains" as well as the "brawn" for our industrial life. Automation—the much discussed subject nowadays—is unthinkable in practical terms, without electrification.

In some cases, automation might eliminate the need of human brains to operate an already established and tuned-up production line, but it obviously cannot by itself create or invent a new process. In other words, automation is merely a sign or result of technical progress, but is neither its cause, nor its source. It is still the human brain that provides the necessary impulse, that creates constructive dissatisfaction with the present, and paves the way to a better future. It is in this field that the electrical engineer in industry fully comes into his own, and the magnitude and scope of his tasks are broad and far-reaching.

In a typical industry, he is concerned, first of all, with the problem of power distribution in his plant; a large task in itself if you remember that this now involves over 300-billion kwhr per year. In many cases, when his industry is endowed with by-product power, he must be engaged in power generation, reaching in a number of plants into hundreds of thousands of kilowatts. Then, and foremost, he must take care of proper utilization of this energy in the form of power, heat, and light. To do so, he must combine several electric products into a coordinated system, and then he must blend the latter with the technological process and machinery used in his industry. Ideally, in addition to the mastery of electrical engineering, he must be fully conversant with the industrial processes, as then only can he effectively and efficiently electrify them; then only can he think of ways of improving these processes. In short, the electrical engineer is the spark plug of progress, the cross-fertilizing agent in his industry—whether he himself, or others, realize it or not.

It is abundantly evident that no engineer can fully develop himself without association with his fellow engineers pursuing similar work. Here is a clear-cut task for technical societies like our own AIEE. The Institute will find its expanding activities in industry both constructive and rewarding. The regular AIEE Technical Committees and Industry Conferences, such as have lately been established in the rubber, textile, machine tool, petroleum, paper, and other industrial lines, provide the needed focal points to organize and bring together the electrical engineers working in these industries. This promotes sound engineering, stimulates engineering progress, and extends the AIEE influence in new and expanding fields.

There is another question which should loom prominently in our minds. How can we reconcile the expected rapid growth of our industrial life with the threatened shortage of engineering graduates? That this shortage exists is beyond doubt. Much has been done, and more has been proposed to alleviate this situation. Fundamentally, however, we can readily resolve this problem by the already existing means at our disposal.

In the first place, the old and reliable law of supply and demand should, and will, effectively function to make the engineering career economically attractive, both to young graduates and to more mature men. The effect of this law is cyclic in nature. In order to shorten the cycle and to accelerate the process, no effort should be spared in airing this problem publicly, again and again.

Second, the industry will find it expedient to provide engineers with more outward signs of respect and recognition—with trappings of office if you will—which are just as important for human morale as the paycheck. Men appreciate gold braid as much as they do gold coin.

Last, but far from least, the engineers, particularly the younger ones, are best attracted not only by good pay and professional recognition, but also by the opportunity to learn, and to further develop themselves as engineers. More and more, industry calls for men either having, or capable of developing, the vision, grasp of fundamentals, and knowledge of modern analytical techniques. Many industries can offer young men not only interesting work, but also the opportunity of being schooled in such new advanced disciplines as, for instance, power applications, feedback control, electronics computer studies, and others. It is gratifying to observe that the young generation usually places this opportunity to learn on the top of its list of requirements. Our experience shows beyond reasonable doubt that when this opportunity exists, the young electrical graduates are eager to enter the rapidly growing and promising industrial activity.

All these factors make me feel certain that our engineering progress in industry will not dry up due to a manpower shortage. This is indeed a field of unlimited possibilities; of great romance and fascination.

As a self-appointed representative of electrical engineers in the industry (for today), and on their behalf, I gratefully accept the 1955 Edison Medal.

Turbine-Generator Insulation Testing

J. E. MULAVEY
ASSOCIATE MEMBER AIEE

The problem of evaluating the condition of generator insulation seems to be general throughout the industry. This article deals with recent experiences of the Detroit Edison Company with direct high-voltage testing.

AN INSULATION TEST WITH A MEGGER was relied upon for many years to evaluate the condition of generator insulation. Experience proved this test a sensitive detector of moisture; thus when a historical record of insulation resistance and temperature was accumulated for each piece of equipment, this test provided a relatively simple criterion of the condition of insulation. Later, the absorption test was added along with the polarization index feature. Proof testing with alternating current has never been adopted as a periodic test on main units at The Detroit Edison Company, Detroit, Mich., because of its destructive nature. During 1940 and 1941, power-factor tests were made on 20 main turbine generators, comprising 1.25-million kva. The results did not reveal any alarming conditions so the test was discontinued partly because of the incidence of World War II. However, the machine which had the highest power factor, 8.9 per cent, later failed in service, which may have been a coincidence since another machine with 8.4-per-cent power factor is still in service. During this early period, 1925 to 1942, the operating record was good as only one machine failed in service. In fact, only one service failure has been experienced to date.

In recent years, the situation has become more critical. Where formerly, machine obsolescence removed from service old windings before they had worn out, now many main units with insulation 30 years old are still in use. Some of them will be in use at least another 10 years. In fact, 14 of 35 main turbine-generator units are 25 to 35 years old. These old machines range in size from 10 to 50 megawatts (mw), and total 550 mw in a system total of 2,400 mw. The success that others have reported with direct high-voltage testing led to an investigation of the possibilities of this relatively new method.

On the basis of results obtained by The Detroit Edison Company during the past 3 years, four old machines have been rewound and ten have been cleared for further service; one of the ten was repaired. While attention has been focused on the old windings, all new main units and some middle-aged units have been tested with direct high voltage. Recently, advantage was taken of the availability of the old coils in one of the rewinds to make extensive tests with a view to determine the ultimate strength of 30-year-old insulation. The plan was to isolate each of the 126 coils, test every alternate third coil to destruction with direct, 60-cps, or impulse voltage.

PERIODIC TESTS

ALTOGETHER, 21 main units have been tested with direct high voltage. Of this number, 13 units gave test results which were acceptable. In the interest of brevity, only one curve of a typical good winding is shown in Fig. 1. However, each of the remaining eight units presented a special problem and, therefore, each one will be discussed briefly under separate headings. It will be noted that the direct high-voltage test was very helpful and in only one case did it fall short of expectations.

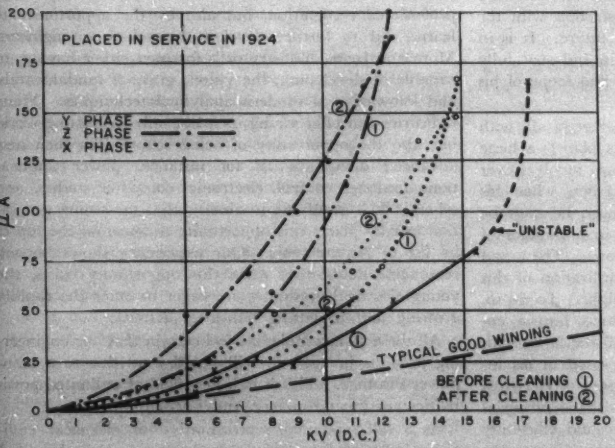


Fig. 1. Direct high-potential tests before rewinding, number 2 main turbine generator

Full text of paper 56-51, "Testing of Main Turbine-Generator Insulation," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

J. E. Mulavey is with The Detroit Edison Company, Detroit, Mich.

The writer wishes to acknowledge the assistance and co-operation rendered in this work by C. S. Arthurs, J. E. Atkinson, R. T. Curto, D. E. Davison, F. M. Duff, H. R. Harris, and R. D. Hillier of The Detroit Edison Company.

Power-factor data are included wherever they are available on the eight units. In general, when other high-voltage a-c tests are made, power factor is measured with a simple unshielded wattmeter, ammeter, and voltmeter circuit, which provide useful information.

Turbine Generator Number 2, Trenton Channel. This machine is rated 50 mw, 62½ megavolts-amperes, 12.2 kv, 1,200 rpm, 60 cps, 6 poles with 126 slots, coil wound with three turns per coil. It was placed in service in 1924, and all of the original coils appeared to be in good condition. The historical record of absorption tests and the polarization index were good.

While the machine was down for a 3-year overhaul, a direct high-voltage test was applied. Fig. 1 shows the results of this test. Microampere leakage is plotted against applied voltage. The voltage was increased slowly, stopping at each 5-kv step to allow the current to settle before advancing to the next step. Altogether, about 45 minutes was required for each phase. It was intended to apply up to double rated voltage or 24.4 kv, but the current became unstable at 15 kv. The end-turn insulation was cleaned as well as possible without removing the rotor and the test repeated. No significant improvement was obtained. Power factor measured 8.8 per cent at 5 kv. A 60-cps withstand test of 16.5 kv was applied to determine if the unit was suitable for further service. Two of the three phases failed on this test, but the *Y* phase, which had showed up the worst on the direct-voltage test, withstood the 16.5-kv 60-cps test. On this particular machine, the correlation between direct- and alternating-voltage breakdown values is not very good.

The erratic behavior of the direct-voltage test on *Y* phase of this machine is of special interest because nothing like it had been experienced on other machines. It was strongly suspected that a direct path to ground through the insulation was providing the equivalent of a gap spill-over. Steps were taken to run down the weak coil. Fig. 2 shows quite clearly that failure occurred in a direct radial path through the insulation in contrast to the usual failure which follows a devious path. This coil was located in the bottom of slot *90* and the fault occurred on the turbine side at the end of the slot. Fortunately, the defective coil was the second one from the neutral in a series of seven coils per phase. It was decided to completely rewind this unit because it was not considered practical to repair a coil-wound stator.

It should be noted that the d-c test did not produce complete breakdown of the insulation as there was no avalanche of current such as other investigators have reported. This may have been caused by the low capacity of the direct high-voltage source.

The extensive tests on isolated coils previously referred to were made on this unit, and the data will be found under the heading "Individual Coil Tests."

Turbine Generator Number 3, Trenton Channel. The stator of this generator was tested with the intention of applying up to double rated voltage or 24.4 kv direct current. However, the extrapolated leakage curves indicated that failure might occur at about 19, 15, and 12.5 kv direct

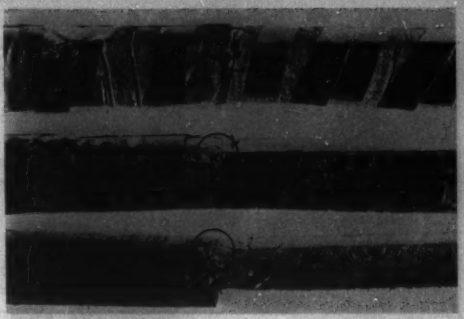


Fig. 2. Coil failure, bottom of slot 90, turbine end, number 2 main turbine generator

current, respectively, on the *X*, *Y*, and *Z* phases. Power factor measured 13.3, 12.0, and 14.3 per cent at 10 kv. A 16.5-kv a-c withstand test was applied, and *Z* phase failed at 14.3 kv. This was a coil winding, identical with that of the number *2* unit previously discussed, so it was necessary to rewind it. The *X* and *Y* phases failed at 20 and 21.5 kv on a standard rate-of-rise a-c test. Like number *2*, this unit was installed in 1924.

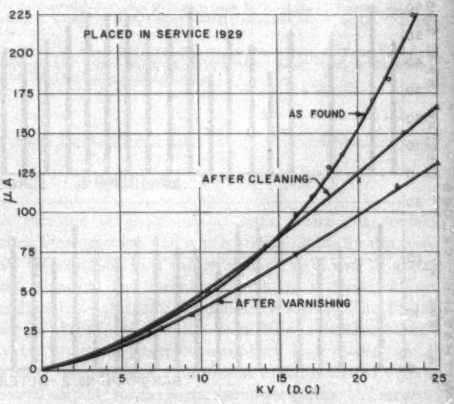


Fig. 3. Direct high-potential tests, number 6 main turbine generator

Fig. 4. Test setup for a-c, d-c, and surge tests of old stator coils, number 2 main turbine generator

Fig. 5. Old stator coils isolated for tests, number 2 main unit

Turbine Generator Number 4, Trenton Channel (*A machine successfully repaired*). The stator of turbine generator number *4* was tested while it was down for overhaul. Two phases tested satisfactorily, but the third gave evidence of impending failure at 16 kv direct current. It failed at 10 kv on a 60-cps test. As this was a bar winding, it was possible to replace the defective coil, whereupon the repaired winding tested satisfactory and the unit was returned to service.

Turbine Generator Number 5, Trenton Channel. A routine direct high-voltage test indicated the ultimate strength of the stator insulation to be about 16, 18, and 16 kv respectively, on the *X*, *Y*, and *Z* phases. Dielectric failures occurred at 16.5, 12.3, and 15 kv rms. The faulted bars were cut out, and failures again occurred at 16.5, 14, and 16.5 kv. Deterioration appeared to be general throughout the machine so it was rewound. This was a bar winding, installed in 1927.

Turbine Generator Number 6, Trenton Channel (*A machine successfully cleaned*). The microampere leakage versus direct-voltage curves of Fig. 3 tell the story of this unit; only one phase is shown, as all three phases had similar curves. Serious consideration was given to rewinding this unit after the first test, but cleaning and varnishing made so much improvement as shown by the d-c test, that rewinding was deferred. Before the unit was returned to service, it withstood a 16.5-kv a-c test. The power factor at 10 kv measured 9.55, 9.27, and 9.30 per cent, respectively, on the *X*, *Y*, and *Z* phases. It is planned to recheck this machine. It was placed in service in 1929.

Turbine Generator Number 6, Marysville. Examination of the end-turn insulation, at the time of the direct high-voltage test revealed numerous cracks. Grounded metal

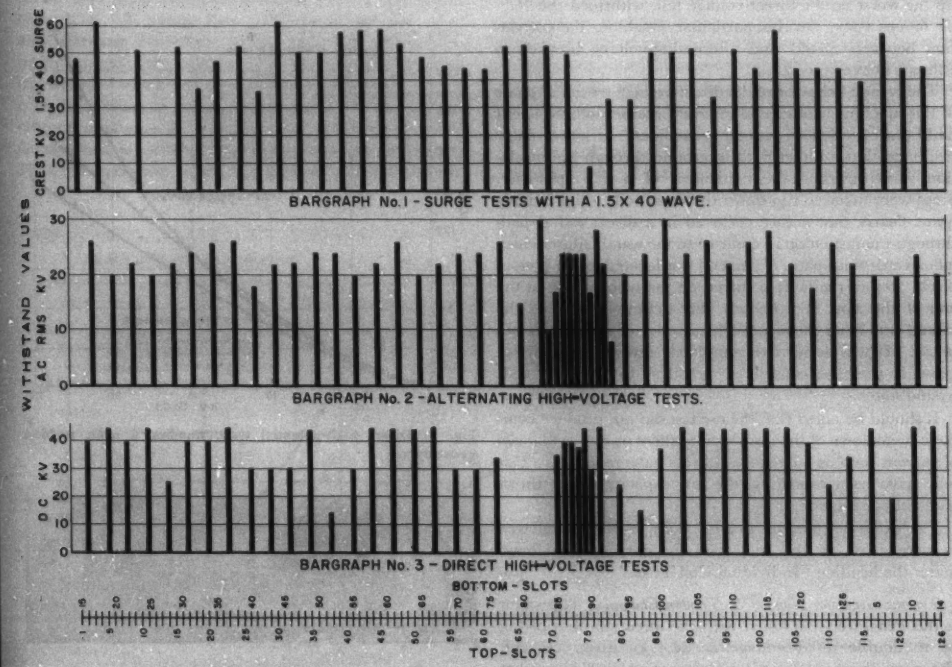

WITHSTAND VALUES
CREST KV 1.5 X 40 SURGE
BARGRAPH No. 1 - SURGE TESTS WITH A 1.5 X 40 WAVE.
AC RMS KV
BARGRAPH No. 2 - ALTERNATING HIGH-VOLTAGE TESTS.
DC KV
BARGRAPH No. 3 - DIRECT HIGH-VOLTAGE TESTS
BOTTOM - SLOTS
TOP - SLOTS

Fig. 6. Bargraphs of tests of isolated coils, number 2 main unit

foil was applied over the suspected areas and the d-c test repeated. The test showed that the surface cracks were not very deep because the leakage current did not increase. The end turns were varnished before the machine was returned to service. This unit was commissioned in 1930.

Turbine Generator Number 15, Delray (Insufficient terminal clearance). The routine direct high-voltage test on this unit is mentioned because of faulty test procedure on the initial test. It was not convenient to obtain enough clearance to connecting copper at the line terminals, so slabs of 1/2-inch thick micarta were inserted. The leakage current versus voltage curve showed a very sharp rise at 15 kv. However, when sufficient clearance was provided, a very satisfactory leakage curve was obtained up to 28.8 kv.

This was a 75-mw 1,800-rpm 60-cps unit. All of the aforementioned units were 50-mw 1,200-rpm machines. The next unit to be discussed will be a 30-mw machine.

Turbine Generator Number 8, Conners Creek. This 30-mw 1,800-rpm 60-cycle unit had one phase with an indicated strength of 13 kv on the direct-voltage test. It failed on a 60-cycle test at 14 kv. The defective bar was cut out, but failure again occurred at 13 kv alternating current. A spare set of coils was available, so the unit was completely rewound.

INDIVIDUAL COIL TESTS

THE INDIVIDUAL COIL TESTS made on coils of turbine generator number *2* are discussed in the following paragraphs. Fig. 4 shows assembled test equipment, and Fig. 5 shows the generator with the coils isolated for test. The significant test results are given in the bargraphs of Fig. 6. It was not possible in some cases to get sufficient clearance to ground where the end turns were cut, and some flashovers occurred before failure took place. For this reason, the actual insulation strength is somewhat higher than the tests indicate.

Direct-Voltage Tests. Voltage was applied in 5-kv steps and the current allowed to settle, usually 5 minutes at each step. Bargraph number *3* of Fig. 6 shows that insulation strength was fairly uniform throughout the winding and averaged about 40 kv. Every third coil was tested. The values shown are withstand values.

Sixty-cps Tests. This was a step-by-step test. Ten kv was applied for 1 minute and then increased in 2-kv steps of 1 minute each. The withstand values are plotted in bargraph number *2*. Again the insulation strength appears quite uniform throughout and the average is about 25 kv.

Surge Tests. The remaining coils were given a surge test with a $1^1/_2$ by 40 wave. The first test on each coil was at 20 kv; on each succeeding test the voltage was increased about 10 kv until failure occurred or end flashover took place. Bargraph number 1, Fig. 6, shows that coil strength was again uniform and that average withstand strength was 45 kv. The withstand voltage is the crest value of the impulse wave.

The necessity of rewinding a machine which displayed so much strength on the forgoing tests may be questioned. Reference to Fig. 6 will show that there were several weak coils distributed throughout the winding, and it would not be practical to replace coils in a coil-wound stator.

Correlation of D-C to A-C Tests. The tests on individual coils indicate an average d-c strength about 1.6 times the average a-c strength. However, when complete phases have been tested to destruction, this ratio has been found to be about one to one, based on the projected d-c strength.

CONCLUSIONS

DIRECT HIGH-VOLTAGE TESTING has been found to be a very satisfactory method of evaluating the condition of generator insulation. It is generally possible to anticipate insulation failure without breaking it down. However, one experience indicates that failures can occur without warning even though the test is conducted with the greatest care.

The isolated coil tests reveal that 30-year-old insulation may have surprising strength. The surge strength of this old insulation is particularly impressive.

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Stereo Reverberation

A shortage of good concert halls means that music is often presented in a hall which is less suitable for this purpose, for example, in a theater. Such halls can be given better acoustics for music by providing artificial diffuse reverberation. An installation is described in *Philips Technical Review*, with which such "stereo reverberation" can be provided electroacoustically. It is based on a so-called "delay-wheel," the rim of which is coated with a material suitable for magnetic sound recording. A recording head records the music performed. A number of play-back heads (four or six) around the circumference of the rotating wheel pick up the recorded sound with predetermined time lags, and separately feed a group of loudspeakers, mounted throughout the hall. The intensity of each group is independently controllable, and the time lags can be regulated by the speed of the wheel. The sound is picked up by one or two "line microphones," each consisting of ten condenser microphones with strongly directional characteristics, to reduce the possibility of continuous "howl-back." This produces a great improvement in the acoustics of a hall, and the performing musicians are aware that it makes the hall more "playable."

Using Analogue Computers in Power System Studies

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IN THE PAST FEW YEARS a great interest has developed in the use of digital computers for solving the engineering problems of utility companies. The utility engineer already was familiar with the use of computers such as the network analyzer for power system studies, but many types of problems were encountered which were either long and tedious or impossible of solution on the network analyzer. As digital computers became more available, often because they could be bought or rented for use by both the engineering and accounting staffs, the engineer turned to them as a new tool for solving his problems. In doing this, he often overlooked the new methods that have been developed in analogue computers.

Analogue computers can be divided into the direct and operational types. Most of the original analogue computers were of the direct type. An example is a network analyzer in which the impedance of the lines is represented directly by impedance, voltage by voltage, and current by current. In the operational type of computer, summing and integrating amplifiers are used to represent the equations of the system. By combining one of these operational analogue computers with a network analyzer, the door is opened to the solution of many new types of problems, such as studies of automatic voltage regulators, automatic dispatching systems, etc. In addition, many of the more conventional problems, can be solved much faster and much more easily because the analyzer will become semiautomatic.

Northwestern University has recently set up a new computational laboratory which contains both a network analyzer and an operational analogue computer. The two units are in the same room and are so arranged that they can be used either together or separately. The network analyzer was developed and built at the university and has been described in detail previously.[1] The operational analogue computer is a standard commercial model.

A new type of generator unit has been designed for the network analyzer which serves the double function of making the process of problem solving more automatic, and acting as a device for coupling the analogue computer and the network analyzer. With this unit, the desired magnitudes of voltage output and power output are obtained directly by adjusting two control knobs. These quantities are then automatically maintained at the desired levels.

Jacks are provided for making connections to the analogue computer so that analogues[2] for the synchronous machine which include the effects of inertia, saliency, and flux decay together with the effects of voltage regulators, governors, and other control equipment can be set up. Thus, the problem-solving ability of the network analyzer can be greatly increased.

As an example of the type of problem which can be solved using the two computers together, a system was set up which consisted of a synchronous machine with a voltage regulator connected through a reactance to an infinite bus. A transient was applied to the system by opening the transmission line connecting the machine to the infinite bus for approximately 0.14 second and then reclosing it. The resulting swings of the machine's angle, terminal voltage, field voltage, and field current, as traced by the recorder, are shown in Fig. 1.

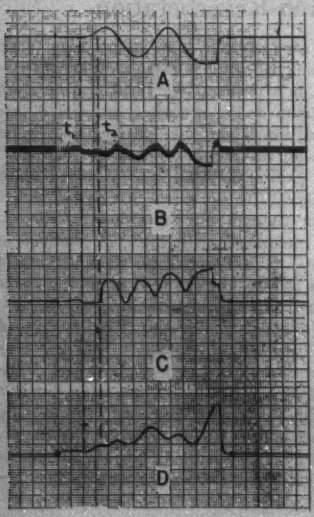

Fig. 1. Results from sample problem: *A*, power angle δ; *B*, terminal voltage V_t; *C*, field current i_f; *D*, field voltage e_f

With these new facilities the university will be better able to fulfill its proper role with respect to the electric power industry. Many new types of systems and problems can be studied, and the necessary research carried out to provide a foundation of knowledge needed for further advancement of power systems. This research can be done in two ways, by the faculty directly and by graduate students interested in the fields of power and control. An active group working in this field cannot help but give the undergraduates an impression that this is an active and interesting field, thus helping to attract able students to it.

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Sonance Design of Large Induction Motors

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MOTOR NOISE must be reduced to ever lower levels to meet the new demands of motor users. Today, an increasing awareness of noise is largely caused by the progressive mechanization of our lives, requiring use of noise-producing machines, as well as by the emphasis in recent years on physiological and psychological effects.

At present, no reasonable sound level can be set, which will ensure that if the noise produced by a motor is below this level it will be satisfactorily quiet in all applications. Acceptable sound levels and characteristics must be determined for each type of application and, in some cases, for individual motors. For determining the acceptable noise levels, there is a need for a meaningful standard.

The physical factors that make an induction motor a machine for converting electric energy into mechanical energy, also make it a machine for converting this energy into acoustical energy. The problem of "sonance design" is to reduce the acoustical efficiency of these machines so that they will produce less noise. Induction-motor noise may be classified in three main groups: (1) magnetic noise; (2) mechanical noise; and (3) aerodynamic noise. All three kinds of noise are generally produced by any motor and any one kind may be predominant depending upon the type of motor. Magnetic noise is produced by mechanical vibration of the motor frame or components, where the vibromotive force is supplied by the magnetic fields of the motor. Mechanical noise in induction motors is caused by rotor unbalance, bearings, and the effects of mechanical fits and tolerances. Magnetic and mechanica' noise can be minimized by good design and manufacturing techniques. These types of noise usually are not a serious problem in large motors.

Aerodynamic noise is often the predominant noise produced by large induction motors. This is a broad classification that includes fan noise, air-flow noise, and the noise produced by the siren action of radial rotor and stator ducts. Numerous tests on motors have shown that, where fan noise is predominant, the sound energy produced varies approximately as the 5th power of the peripheral velocity of the fan-blade tips. All types of fans of the same capacity do not make the same amount of noise, but the fans on a high-speed motor can produce objectionable sound levels even when optimum designs are used. In motors that have radial ducts in the rotor and stator for ventilation, the predominant noise is often that produced by the siren action of these ducts. This noise is more objectionable than fan noise in that it is a pure-tone high-frequency noise. To reduce this noise, the siren should be made as inefficient as possible, but at the same time there are certain air-flow requirements to be maintained.

In spite of good design practices, if nothing additional is done to reduce the aerodynamic noise, objectionable sound may be produced by large motors. It is then necessary to employ other means of reducing this noise to satisfactory levels. One such method is the use of dissipative-type mufflers. These mufflers are constructed in such a way that the air entering and leaving the motor must make a series of 90° and/or 180° bends. This duct work may be lined with sound-absorbing material, and can be effectively used to reduce aerodynamic noise. As an example, the effectiveness of acoustic treatment of the air intakes and exhausts of a 4-pole open dripproof motor of several-thousand horsepower will be considered. The predominant noise produced by this motor without the acoustic treatment was duct noise. The rotor of this machine produces a pure tone noise at about 2,300 cycles per second.

It must be recognized that the noise this motor will actually produce may vary considerably, depending on its acoustic environment. Sound-pressure-level data represent the noise the motor would produce under a given set of conditions. It is desirable, therefore, to rate the noise produced by the motor on a sound-power basis, because the sound power produced is essentially unaffected by environment, whereas the sound-pressure level is environment sensitive. The sound power produced determines the latent ability of a motor to produce noise. Through the use of sound-power data, the distance factor usually associated with noise measurements is eliminated, and this data can be used to predict the noise that will be produced under a variety of conditions. Sound-power data also provide a better means of comparing the noise produced by motors of various sizes and shapes. The following data show sound-pressure level and sound power as functions of frequency for the motor with and without the mufflers.

	Motor without Mufflers (1)		Motor with Mufflers (2)		(1)–(2)	
	Sound-Pressure Level,* Db	Sound Power, Watts	Sound-Pressure Level,* Db	Sound Power, Watts	Sound-Pressure Level,* Db	Sound Power, Watts
Total	98	0.293	86	0.033	12	0.260
Octave Bands						
20–75 cps	81	0.011	77	0.005	4	0.006
75–150	86	0.022	81	0.013	5	0.009
150–300	88	0.033	80	0.009	8	0.024
300–600	85	0.016	70	0.001	15	0.015
600–1200	87	0.023	68	0.001	19	0.022
1200–2400	94	0.112	76	0.004	18	0.108
2400–4800	91	0.066	73	0.002	18	0.064
4800–9600	84	0.010	62	0.000	22	0.010

*Sound pressure level in db: 0.0002 dynes per square cm.

The importance of noise control is obvious, and noise measurements are often an important part of any noise-control problem. The advantages of the latest noise measurement techniques and noise evaluation criteria make it desirable to include such practices in noise measurements.

Digest of paper 55-724, "Sonance Design of Large Induction Motors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955. Published in AIEE *Power Apparatus and Systems*, December 1955, pp. 1189–92.

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Cineroentgenography with Image Intensification

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X-ray studies of the internal workings of critical moving components have been hampered until recently by the inability to obtain a satisfactory brightness level. Through use of image intensification, it is now possible to make X-ray motion studies in many applications previously considered impractical.

STOPPING THE MOTION of a bullet in a microsecond after impact with armor plate, and stopping flow of metal during the pouring of a casting has been accomplished by the use of X rays. In order to obtain a satisfactory analysis of each, two entirely different X-ray units were required.

It is interesting to note that these X-ray studies of objects in motion have been done primarily in the research laboratories, far removed from production. A recent diversion from this tradition was the inspection of some arsenal items on a production basis.

It seems logical that records should be kept of the internal workings of the critical moving components used on aircraft, ships, and mechanical and electrical apparatus. The obstacle to such progress has been the inability to obtain a satisfactory brightness level for photographing the fluoroscopic screen on a continuous basis, or the lack of a series of images to provide a satisfactory analysis. An image intensifier can be used to increase the image brightness to a satisfactory level for X-ray motion studies for many objects previously considered impractical.

EXISTING X-RAY METHODS

BEFORE THE APPLICATION of image intensification is discussed, the major X-ray systems used in the study of motion will be reviewed. A better perspective of the thickness of metal penetration, number of exposures, maximum velocity of the object, and the quality of film for each system will thereby be obtained.

The characteristics of each system are outlined in Table I. The first requirement of studying objects in motion is that the exposure be short enough to stop motion. Note that as the exposure time is decreased, the size of the focal spot increases appreciably. Since film blur increases with the size of the focal spot, it is desirable to keep its size as small as practical by choosing X-ray equipment which will just stop motion. For this work, motion is considered stopped when film blur is approximately 0.15 mm.

The equipment which can produce suitable short time exposures should then be narrowed to the group that can provide the minimum sequence of exposures needed. It is desirable to keep the number of exposures low so that the best contrast available can be obtained through a low voltage and high current.

The next step should be to narrow the second group to those capable of penetrating the object with satisfactory contrast. This information can be obtained from radiographic tests with a standard X-ray unit. The milliampere-seconds at the maximum voltage that will provide satisfactory contrast can then be compared to the milliampere-second output of one of the available units. If all of the conditions can be met with more than one unit, the unit having the smallest focal spot should be chosen in order to obtain the best definition.

The advantages and limitations of each major X-ray system for studies of objects in motion may be described as follows. Fig. 1 shows the Micronex unit.[1,2,5] It is used chiefly in the studies of projectiles but its exposure time of 1 microsecond is capable of stopping motion for many other studies. It is capable of penetrating an inch and a half of steel by the use of high-speed film and intensifying screens. The X-ray tube operates at voltages up to 360 kilovolts when in oil, has an anode current of 3,000 amperes, and a focal spot of 13 × 19 mm. Besides the film blur from the large focal spot, there is the limitation of being unable to obtain an exposure more often than every 3 seconds. This has been partially overcome by the use of up to 4 surge generator units situated at different angles. Each X-ray tube is

Table I. Comparison of X-Ray Systems Used for the Study of Objects in Motion

X-Ray Unit	Minimum Exposure Time, Microseconds	Total Exposure	Penetration of Steel	Focal Spot Size, Millimeters
Fractional microsecond, 100 kilovolts (milliamperes vary with capacitance)	0.1	1 every 3 seconds (25 exposures)	1/32 inch	13×19
Micronex, 360 kilovolts, 3,000 amperes	1.0	1 every 3 seconds (25 exposures)	1½ inches	13×19
X-ray movie, 150 kilovolts, 60 amperes	10.0	200 exposures in 2 seconds	1/4 inch	3×10
Image amplifier with rotating anode tube and special control, 150 kilovolts, 0.006 amperes	2,777 (30 frames per second with phase shift)	Continuous, or fewer exposures at high currents	1/2 inch, continuous (6 milliamperes) 1 inch, 1/2 second (210 milliamperes)	0.3×0.3
Standard industrial X-ray unit, 150 kilovolts, 0.006 amperes	5,555 (30 frames per second	Continuous, low current only	1/8 inch	2.3×2.3

Revised text of a conference paper presented at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955, at a session sponsored by the AIEE Committee on Electronics.

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then controlled independently and may be fired within microseconds of the other.

After considerable work had been done with the Micronex, problems arose which required shorter exposures and more contrast. Several laboratories throughout the country designed special circuits to operate at 100 kilovolts for 0.1 microsecond, using the same X-ray tube as is used on the Micronex. In some cases, the glass of the X-ray tube was reduced by 1/2 to give the higher X-radiation output and a better contrast. This technique is used in the study of detonation explosion produced shock waves in metal, and shape charge phenomena. Some of this work has been reported by Breidenbach of the Aberdeen Proving Grounds.[4]

Compared with the Micronex, the 0.1-microsecond units give better contrast for thin sections of metal, and shorter exposures. However, the penetration is considerably less than with the Micronex. Since the exposure rate is 1 every 3 seconds, multiple units can be used to obtain multiple exposures as is done with the Micronex.

The next application of X rays to the study of motion was to provide a longer sequence of exposures for motions requiring exposures of 10 microseconds. Such a unit was designed under contract with the United States Navy for the study of rocket propellants and is commonly referred to as an "X Ray Motion Picture Unit"[3] (Fig. 2). This unit has a maximum of 150 kilovolts supplied across the tube by a pulse transformer within the tubehead. It can take 200 frames at a rate of 50, 100, or 150 frames per second directly on film or by photographing a fluoroscopic screen. Due to the inefficiency of the collection of light by means of lenses, and the persistence of a fluoroscopic screen, it is preferable to use film directly. The film is moved in one continuous motion over a drum coated with material used in intensifying screens. The big advantage of this type of unit over the previous two is its ability to take multiple exposures. Another advantage is its smaller focal spot of 10 by 3 mm. Its longer exposure time, and the small exposure field of $2^1/_2$ by 8 inches would not be satisfactory for some of the problems solved by the previous two units.

In 1945, some studies with X-ray motion pictures of the pouring of castings were reported in the British magazine *Foundry Trade Journal*.[6,7] These studies made use of a standard industrial 140-kilovolt unit having a stationary target and a 2.3- by 2.3-mm focal spot. It showed the effect of rate of pouring when using different shaped runners, the importance of venting, and the growth of shrinkage cavities. This work was done by photographing a standard fluoroscopic screen.

Very valuable information was gathered in these studies. It was suggested that future work be aimed in two directions: one, at the investigation of very thin sections of supercritical material; and the other, at heavier castings.

IMAGE INTENSIFIER POSITION FOR MOTION STUDIES

PRELIMINARY LABORATORY TESTS indicate that a substitution of the image intensifier at the film position of the Micronex and fractional microsecond units would not permit the penetration of thicker sections. The intensifying action of the image tube cannot match the effect of the fast film and front and back intensifying screens. In the case of the "X-Ray Movie Unit," rough calculations indicate that the penetration range could be extended from 1/4 inch to about 1/2 inch of steel. The field of study would be changed from the $2^1/_2$- by 8-inch area to a 5-inch circle, the movement of the film would be greatly simplified, and the blur due to motion eliminated. It is not known at this time whether screen persistence would be a problem.

The foundry work on thin sections of supercritical material could most suitably be investigated by the use of rotating anode X-ray tubes operated at high milliamperage for short exposure times. This technique would give good sensitivity by using lower voltages for high contrast, and better definition with the available focal spots of 0.3 mm or 1.0 mm.[5]

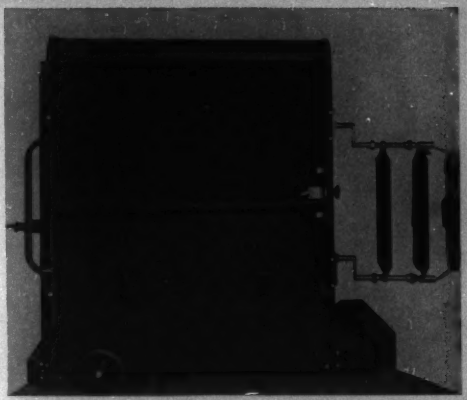

Fig. 1. Surge generator of Micronex unit. Six capacitors are charged in parallel then discharged in series across the X-ray tube

Fig. 2. X-ray movie unit. On the left is the direct-recording X-ray camera in a light-tight enclosure, with height-adjusting mechanism. In the center is the oil-filled tube head which houses the X-ray tube and 50-kv pulse transformer. On the right is the power and control unit

Fig. 3. Cine-Fluorex unit. The X-ray tube is mounted 18 inches below the table top. The image intensifier is mounted directly above, followed by the lens system and camera. The auxiliary control to the right contains the brightness stabilizer and settings for brightness levels and different speed films

The image intensifier can extend the range of metal penetration to investigate the pouring of heavier castings. For example: with a 150-kilovolt X-ray tube operated at 6 milliamperes, motion pictures can be obtained through 1/2 inch of steel with the image intensifier, compared to 1/8 inch of steel with standard fluoroscopy. This penetration can be extended beyond 1 inch of steel by using the short time ratings of rotating anode tubes.

Most of the X-ray systems for motion studies have been used to study biological effects of pressure and acceleration on humans, and the wounding mechanism of projectiles on animals. It is anticipated that the image intensifier with optical system and camera attachment will be used to expand these studies. Westinghouse has developed such a unit for medical applications. It allows the radiologist to obtain a record of a fluoroscopic examination for further study. Normally the only records available would be several spot films. Now it will be possible to take a series of exposures which will show the sequence of barium flow and give the 3-dimensional effect, if desirable, by rotation of the patient.

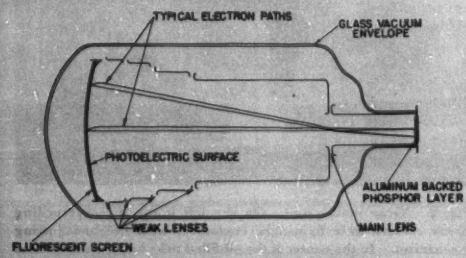

Fig. 4. Simplified diagram of image intensifier tube

These same principles can be applied to industrial problems. For example, if cylindrical objects are being inspected fluoroscopically, and one of them is found to have a fissure or crack, the normal procedure would be to take several radiographs in different orientations. With the Cine-Fluorex, a series of radiographs could be taken to give a more complete record, with the 3-dimensional feature included. Considerable time would be saved, as there would be no setup time required. The operator need only depress a lever to start the camera in operation (Fig. 3).

The main components of the Cine-Fluorex are (1) an image intensifier tube, for intensifying the brightness of the fluoroscopic image; (2) an optical device for viewing the intensified image and also transmitting the same image simultaneously to the cine camera; (3) the cine camera; and (4) the cine control.

Fig. 4 diagrammatically shows the principal components of the image intensifier tube.[9,10] Beginning at the left, the X-ray energy which has been exponentially absorbed by the object, enters the image-amplifier housing and is converted into light by a fluoroscopic screen. This screen is in close contact with a photosurface of cesium antimony which emits electrons proportional to the light it receives.

The electrons are focused by a series of electrostatic lenses on an output phosphor 1/5 the diameter of the input screen. The electrons are also accelerated by the application of 30 kilovolts across the input screen and output phosphor. For normal viewing, the image is magnified back to normal size without apparent loss of light to give an intensification of 200 or more.

Fig. 5 shows the principle of the optical system used in the Cine-Fluorex. It was felt that a convenient method of viewing the fluorescent image while simultaneously making motion pictures of it would be very desirable. The object lens and the camera lens are arranged in essentially a front-to-front system with each lens focused near or at infinity. With this system, the distance between the objective and camera lens is not very critical. The first mirror shown is a partial reflecting mirror which passes about 95 per cent of the light striking it through to the camera and reflects 5 per cent toward the second mirror. This light in turn passes through a 5-inch diameter field lens which forms an image between the third mirror and the output window of the optical device. An observer looking into the fourth mirror may observe this image. The observed image while only approximately 5 per cent as bright as the output image of the image tube is still approximately 10 times as bright as

the fluorescent image at the input end of the image intensifier tube even if a tube with minimum intensification is used.

In the actual commercial unit, an additional mirror is used at the position of the first mirror. This mirror is a full silvered, front surfaced mirror which reflects all the light impinging upon it, less the losses. It can be moved in front of the first mirror or back out of the light path by means of a lever on the outside of the optical unit. With this mirror in the light path, all of the light impinging upon it is reflected toward the observer and none gets through to the camera. Thus, normal fluoroscopy may be performed at the low radiation levels made possible by the image intensifier. When something of interest is observed of which a film record is desired, it is only necessary to move a lever and the optics are converted in less than one second for taking a film record. The next time the X-ray "on" switch is actuated, the camera operates and records the image of the output phosphor of the image tube.

The camera consists of a 16-mm film magazine, a synchronous motor drive, gears for changing the frame speed, and commutators for synchronizing and pulsing the X-ray machine. X rays are on only when the film in the magazine is stationary. X rays are off when the film is being transported so as to bring the next frame in front of the camera aperture. The camera is designed for two film speeds, 15 and 30 frames per second. By synchronizing the X-ray pulses with the film transport, more efficient use may be made of the load capacity of the X-ray tube as well as more efficient use of available X rays regarding patient dosage in medical techniques.

The cine control contains auxiliary electrical circuits such as the synchronizing and brightness stabilizer circuits, power supplies, and relay circuits necessary to free the operator of the unit of many detailed operations and computations. This control is designed to be connected between the main X-ray control and the Cine-Fluorex unit. The only adjustments necessary for the operator to manipulate are an "on-off" switch and a film selector. The "on-off" switch is used to de-energize the cine circuits in case the X-ray equipment is to be used only for radiography or fluoroscopy for a lengthy period of time. The film selector selects the proper brightness level which the brightness stabilizer is to hold at the output end of the image intensifier for the type of film being used in the camera at the time. It became evident early in the development that some automatic means of brightness control would be necessary to get consistent film density when scanning parts of varying thickness and density with the cine unit.

Fig. 6 shows the variation in film density for varying thicknesses of aluminum for a fixed setting of kilovolts and milliamperes ("KV" and "MA"), as well as with the use of brightness stabilization by a variation of KV and MA. The density from 1/4 to 1¾ inch varies from 1.75 to 2.1 with stabilization, and from 0.4 to 2.67 without stabilization. The significance of stabilization is that the operator can be sure of having the proper film density, and hence optimum sensitivity, without changing any control settings. This is particularly helpful when a sample has a wide variation in thickness from one area of inspection to the next.

The brightness stabilizer consists of a photomultiplier

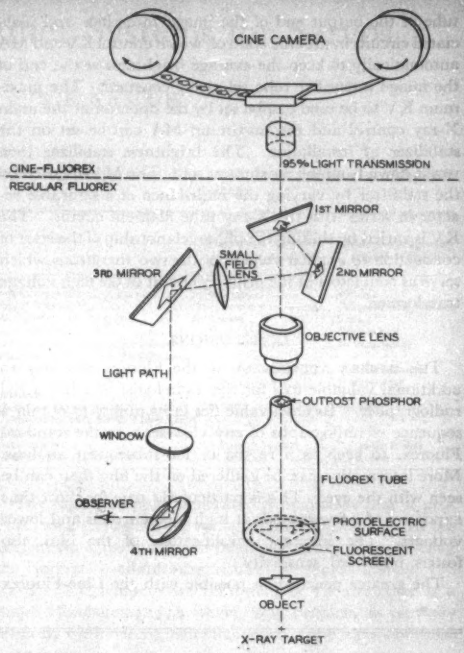

Fig. 5. Simplified diagram of lens system used with image intensifier tube for standard fluoroscopy and cine work

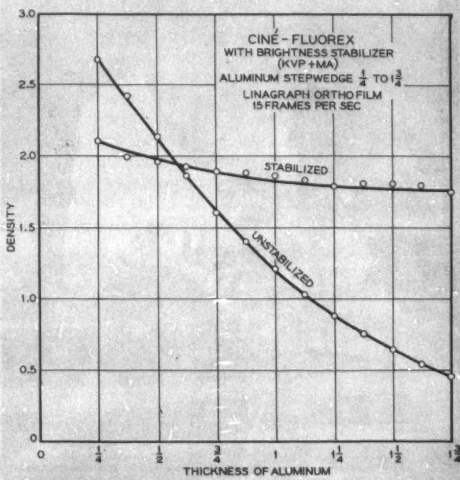

Fig. 6. Graph of the effect of the brightness stabilizer on the light output of the image intensifier with variation in thickness of aluminum

tube at the output end of the image intensifier and associated circuits in the cine control, which control KV and MA automatically to keep the average brightness at the end of the image intensifier tube relatively constant. The maximum KV to be used can be set by the operator at the main X-ray control and the maximum MA can be set on the stabilizer at installation. The brightness stabilizer then works down from the maximums set. The MA is varied by the stabilizer by varying the impedance of a saturable reactor in series with the X-ray tube filament circuit. The KV is varied by shifting the phase relationship of the start of conduction to applied voltage of the two thyratrons which serve as contactors in the primary circuit of the high voltage transformer.

CONCLUSIONS

THE CAMERA ATTACHMENT to the Fluorex provides an additional valuable tool for the radiologist and industrial radiographer. Its chief value lies in its ability to obtain a sequence of radiographs of any view seen on the standard Fluorex, to keep as a record or for subsequent analysis. More information can be gathered on the film than can be seen with the eye. This is particularly true for short time exposures of a few seconds at high tube currents and lower voltages. The inherent amplification of the film also fosters improved sensitivity.

The greater penetration possible with the Cine-Fluorex than with standard cinefluorography allows the inspection of many hermetically sealed units and the study of the pouring of heavier castings than has been previously possible. The sequence of exposures when projected will give the 3-dimensional effect available from object rotation.

Cine-Fluorex also has great value for teaching, since an unlimited number of viewers can discuss the sequence at leisure without being concerned about patient dosage or overloading the X-ray tube.

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Billionth-of-a-Second "Stop Watch" Developed

"Split-second" timing has been given a new degree of meaning by scientists, who have developed the world's fastest "stop watch"—an electronic tube which can time atomic "events" down to less than 1 billionth of a second. Announcement was made by Dr. Clarence Zener, acting director of research, Westinghouse Electric Corporation, Pittsburgh, Pa., who described it as an improved type of photomultiplier tube.

The tube, which strengthens radiations by a sort of "chain reaction" of electrons, employs a new principle of operation. An electron, released by a pulse of radiation entering the tube, strikes the front surface of an exceedingly thin film, similar chemically to common table salt, and "knocks" several additional "bonus" electrons from its back surface. An electric field speeds up these new electrons and "aims" them at a second film, where each one releases more electrons from that film. This increase of electrons continues through several steps, or "stages." The result is that several million electrons are obtained for each one released in the beginning; in this way the tube gets its multiplying effect.

Conventional photomultiplier tubes use thick metal plates, so the electrons must be "guided" through a number of complicated paths. In the new tube, the avalanche of "bonus" electrons moves straight ahead, thus speeding their travel time and preventing "straggling" of electrons from stage to stage, to give the tube its precision and super speed.

Decicycle Magnetic-Amplifier Systems for Servos

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MAGNETIC-AMPLIFIER CIRCUITS, which once were limited to several-cycle delays, have been improved by the availability of high-performance rectangular core materials, as well as by the introduction of circuits which yield a complete response within a half cycle. The adoption of pulse techniques, which employ only magnetic and semiconductor materials, has made it possible to design decicycle magnetic-amplifier systems which have response times in the order of one-tenth to one-hundredth of a cycle of the power-supply frequency. It is possible, as a result, to make response-time delays negligible in many rapid closed-loop systems; also, inherent delays which have introduced undesired phase-lag characteristics in a system can be eliminated effectively.

A decicyle magnetic-amplifier system employs a frequency multiplier to increase the basic supply frequency to a higher multiple and a high-performance magnetic amplifier, operating from the carrier frequency delivered by the multiplier. The foremost problem which arises in the design of a decicycle system is the method of obtaining a reliable efficient frequency multiplier, which will produce sufficient power for the subsequent magnetic amplifiers. Magnetic frequency multiplication can be accomplished for multiplication ratios in the range of 2 to 10 with very good results. For single-phase operations, basic magnetic frequency multiplication can be applied to doublers, triplers, and quintruplers; combinations can provide additional multiplication values, except 7, in the range of 2 to 10.

Multiphase multipliers, which depend upon the addition through time phasing of individual phase pulses across a common output, produce only odd integer multiplication ratios. For multiplication ratios greater than 3, it becomes necessary to introduce phase-changing transformers in order to obtain the required spaced phase voltages. For single-phase power supplies, serious consideration should be given to magnetic pulse transformers. Pulse-transformer systems have been used successfully by Morgan and McFerran[1] for extremely low-level signals.

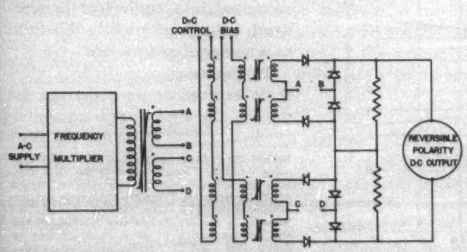

Fig. 1. Sample decicycle magnetic-amplifier system which delivers a reversible polarity d-c output

Table I. Comparative Data and Characteristics of Amplifier Circuits

	High-Performance Half-Cycle Response Magnetic Amplifier	Decicycle Magnetic-Amplifier System
Supply frequency	400 cps	400 cps
Supply voltage	115-volts single-phase	115-volts single-phase
Maximum power output	1 watt	1 watt
Duty cycle	Continuous	Continuous
Control power required for full output	120 microwatts	60 microwatts
Minimum response time for full change in output	1.2 milliseconds	0.2 milliseconds
Minimum signal sensitivity	2 microwatts	1 microwatt
Linearity	5 per cent	5 per cent
Maximum power gain	8,000	16,000
Control frequency for 45° phase shift between control signal and output	50 cps	300 cps
Total volume	7.0 cubic inches	7.5 cubic inches
Total weight	11 ounces	12 ounces

The transistor pulse generator is unique in that it produces an a-c square-wave voltage from a d-c source. At the present time, the maximum continuous output power using the largest available transistors is approximately 100 watts. The temperature limitation of the transistor is a major disadvantage; however, this problem is partially offset by the inherent high efficiencies of the transistor pulse generator.

A choice of the frequency multiplier can be made from the types discussed; the particular selection being governed by the available power source and the desired output characteristics. In accordance with the selection of the frequency multiplier, the magnetic-amplifier design is based upon the output frequency of the multiplier and the degree of performance of the end use.

Fig. 1 represents a decicycle magnetic-amplifier system which can produce reversible-polarity d-c output. Such an amplifier has application in controlling hydraulic-servo valves, d-c servo motors, and other similar devices. The transfer characteristic of a sample decicycle system is linear within 5 per cent. Table I presents data on the general characteristics of a 400-cycle-per-second (cps) system in comparison with the equivalent decicycle system. This table shows that the sensitivity of the decicycle system is improved by a factor of 2, and the response time is decreased sixfold. The improvement in performance of a decicycle system is understandable since the higher frequency supplies permit the use of miniature saturable cores which, in turn, require much lower values of energy for complete reset.

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Evaluation of Unit Capacity Additions

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This article describes a method for evaluating steam–electric additions to an expanding power system, and gives the results of a study made by the Consolidated Edison Company of New York to justify additional investment for larger sized units.

OF TIMELY INTEREST is the subject of the evaluation of steam–electric capacity additions to an expanding system because of the availability of units with capacities roughly twice that of the largest unit in service on some systems, and the promise that even larger units will become available in the future as they become economically justified. Thus, the Consolidated Edison Company of New York, Inc., New York, N. Y. recently made a study to determine the relative economic merits of adding a unit with the nominal ratings of 180, 250, or 300 megawatts (mw) to the system.

That there is an economic relation between unit size and size of system, has been indicated recently by L. K. Kirchmayer, et al.[1] The conclusion thus reached therein is that units with capacities representing 7 to 10 per cent of system peak load can be justified by operating economies and lower incremental investment per kilowatt (kw) of capacity. It concludes that "If above any size the investment cost in dollars per kilowatt remains constant, there will be very little incentive to use units above this size." Earlier H. P. Seelye and W. W. Brown[2] indicated similar reasons for their support of the decision to add two 260-mw units instead of two 200-mw units to the system of The Detroit Edison Company. More recently orders for 300-mw-unit additions to the same system have been announced. Both articles indicate that the attractive feature of the larger units is lower investment per kilowatt of capacity.

Essentially, the problem is the justification of the additional investment for larger sized units. This is generally determined by means of an "economy study," which requires long-range predictions into the future with all of the uncertainties that are inherent in such predictions. The economy study is, therefore, considered to be of a theoretical nature, to be weighed with other factors, both tangible and intangible, and requiring the exercise of a considerable degree of judgment. Notwithstanding the theoretical nature of the economy study, it is an important adjunct in arriving at the ultimate decision. Within the limits of the assumed conditions, it does indicate the relative merits of all alternative proposals under consideration.

METHOD OF ANALYSIS

THE BALANCING OF ANNUAL SAVINGS against annual fixed charges on added investment is fundamental under any method of economic evaluation of alternatives.

This principle was utilized in the subject study to establish the investment that could be justified by the differential annual costs above that for the alternative requiring the minimum investment. Since the annual costs are not uniform in each year of the study period, they were converted into equivalent present-worth values and used in this form as a matter of convenience.

To minimize computations, algebraic expressions were derived for

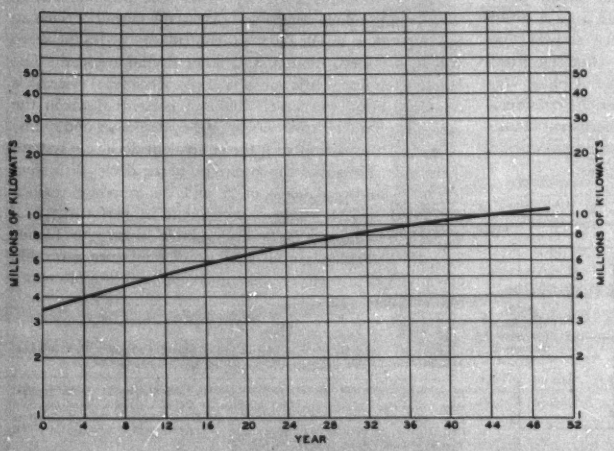

Fig. 1. Estimated system annual peak loads

Revised text of paper 56-19, "Evaluation of Unit Capacity Additions," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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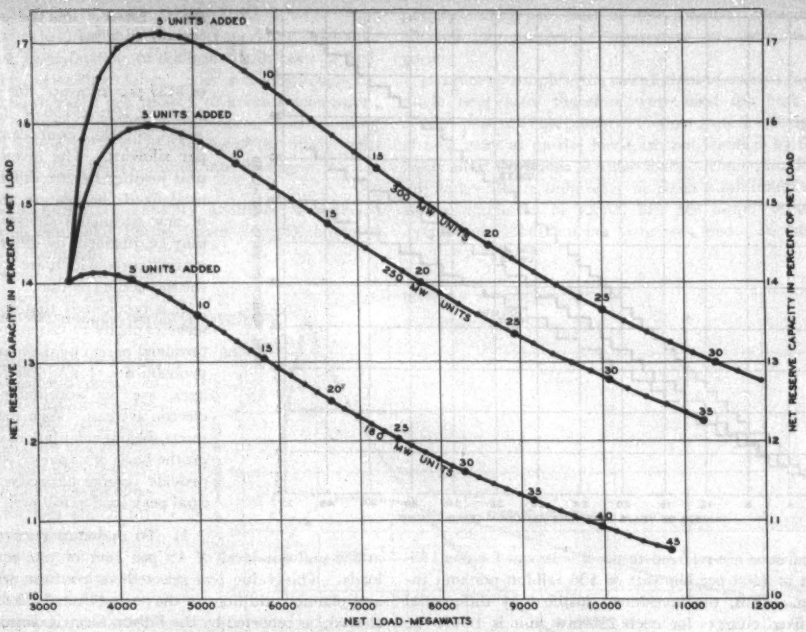

Fig. 2. Effect of unit size on objective reserve-capacity requirements

the present worth of the annual fixed charges as a function of investment per unit, and annual operating costs as a function of over-all or station net heat rate.

By so doing, it was possible to evaluate not only the effect of variation in unit size, but also the effect of variation in thermal performance as influenced by steam pressure and temperature, turbine and cycle design, etc. For the subject study, three present-worth equations, one for each unit size, were utilized to evaluate 20 proposed installations. The derivation and application of the present-worth equations are described in the sections that follow.

PRESENT WORTH OF ANNUAL FIXED CHARGES

ANNUAL FIXED CHARGES of 13.5 per cent are based on a life of 50 years, which is the study period used herein. Annual fixed charges continue from the year of installation to the end of the 50-year study period, and are assumed as lump sums at the end of each year. Investment per unit addition is assumed at the beginning of the initial year of operation.

Under the foregoing assumptions, the annual fixed charges will increase with each unit addition to the system, so that they become a function of the timing of unit additions. For a given predicted rate of peak-load growth, which is shown by Fig. 1 for the subject study, capacity additions are timed to maintain an objective level of reserve capacity. This has been determined by the mathematical probability of loss of load caused by multiple forced outages to average a duration of 1 day in 7 years. For the three unit sizes under study, the objective reserve capacity requirements are shown in Fig. 2. It is obvious by reference to this figure, that this method imposes a penalty on increases in the size of unit additions.

The effect of unit size on the timing of capacity additions is illustrated in Fig. 3, which indicates that the number of unit additions required during the 50-year study period decreases with increase in unit size. However, because of the higher reserve-capacity requirements, the total capacity additions will increase with unit size. Aside from any other consideration, it is obvious that the investment per kilowatt of capacity that can be justified decreases with increase in unit size. Differentials in investment must be justified by differentials in annual fixed charges, and the balancing of the two can be done most readily by conversion of annual fixed charges to equivalent present-worth values by the application of appropriate compound interest formulas to give present-worth factors as shown in Fig. 4.

The derived present-worth values and the investments that can be justified for the larger units relative to the investment for 180-mw units are indicated as:

Unit Size, Mw	Present Worth of Annual Fixed Charges*	Investment Justified per Unit
180	27.674879 I′	1.0000 I′
250	21.132307 I″	1.3096 I′
300	18.259548 I‴	1.5156 I′

* I′, I″, and I‴ = Total investment justified for each unit added to system.

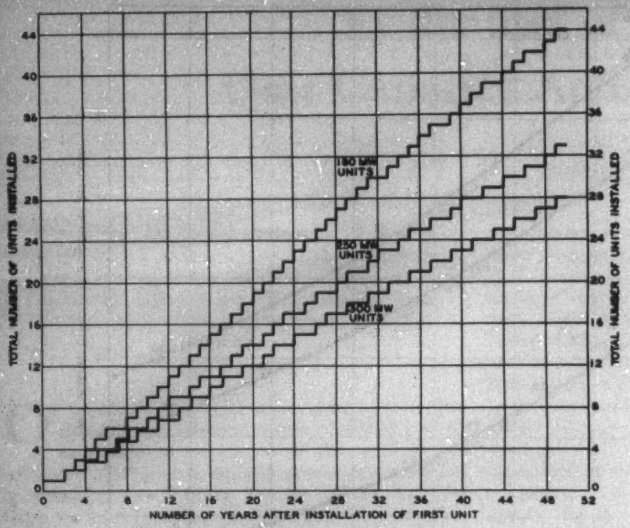

Fig. 3. Effect of unit size on timing of capacity additions

Comparisons are referred to the investment for one 180-mw unit at $200 per kilowatt or $36 million per unit installation. Thus, the investment justified by differential annual fixed charges for each 250-mw unit is 1.3096 × $36,000,000 = $47,146,000, equivalent to an investment of $189 per kilowatt; for each 300-mw unit, it is 1.5156 × $36,000,000 = $54,562,000, equivalent to $182 per kilowatt. The investments per unit justified by the differential annual fixed charges are independent of any additional investments that may be justified by differential operating costs, which are discussed in the succeeding section.

It is recognized that objective reserve capacity requirements, as determined herein by the mathematical probabilities of multiple forced outages, are not acceptable to some electric systems. As a matter of interest, similar calculations were made on the basis of capacity additions to provide reserve capacity above annual peak load as follows:

1. To maintain reserve capacity at the uniform level of 15 per cent of the annual peak loads. This value was selected to conform with actual and planned additions in the period from 1953 to 1958, inclusive; as reported by the Edison Electric Institute power survey[3] for Region I, Northeast.
2. To maintain reserve capacity equal to the capacity of the three largest units on the system. It is not known to what extent this basis is currently being used.

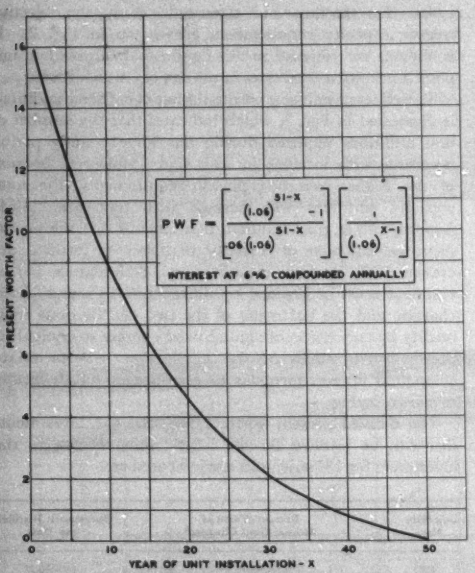

Fig. 4. Present-worth factors applicable to annual fixed charges on investment

A comparison of the objective reserve requirements under the three methods of determination is shown in Fig. 5. In the earlier years of load growth, a 3-unit reserve is considerably in excess of that required by the probability method, and considerably lower in the later years. It is questionable whether a 3-unit reserve would be adequate to provide the necessary margin for contingencies and normal scheduled outages for overhaul, particularly in the later years of load growth.

A 15-per-cent margin of reserve would require less reserve capacity than that determined by the probability method in the early years of load growth, and more reserve capacity in the later period.

A comparison of the investments could justify the 250- and 300-mw units under the different methods for determining reserve capacity requirements. An objective reserve at 15 per cent of the peak loads will be more favorable to the installation of the larger sized units; a 3-unit reserve objective will be less favorable.

In the subject study, differentials in investment for transmission facilities have not been included because extensive studies indicated that unit additions in the near future at contemplated sites, up to capacities of 300 mw each, would not materially affect the system tie capacity requirements. It is obvious, of course, that where this item is pertinent, it should be included as a factor in the economic evaluation.

PRESENT WORTH OF OPERATING COSTS

INVESTMENTS justified by differential operating costs have been limited to evaluation of differentials in costs of fuel, maintenance, operating labor, and spinning capacity. Fuel and maintenance are related to annual generation; labor to the number of unit installations; and spinning capacity to unit size. For the purpose of this study, generating facilities have been classified into three groups:

1. New high-pressure capacity additions as required during the 50-year study period timed (Fig. 3), intended for base-load operation.
2. Existing high-pressure capacity, operating at steam pressures of 900 pounds per square inch (psi) and higher.
3. Existing low-pressure capacity operating at pressures below 900 pounds per square inch intended for peak-load shaving operation and to supply system spinning capacity.

For evaluation of differential costs for fuel and maintenance, the generation by classes of equipment was determined by use of the conventional load-duration curve and companion load-energy curve, for each year of the 50-year study period. To minimize the computations, both the loads and capacities were expressed in per cent of annual system peak. Multiplication of the values on the abscissa of the load-energy curve by the value of the annual peak load permits conversion to annual kwhr. By assuming constant load factor with peak-load growth, a single load-duration and load-energy curve were utilized for this purpose. The loading sequence and determination of generation by classes of equipment are shown in Fig. 6.

Generation by the new high-pressure unit additions was limited to conform with an annual availability factor of 90 per cent or an annual capacity factor of 80 per cent, whichever resulted in a lower generation, as an allowance for normal outages for overhaul. Ten per cent of the existing high-pressure capacity, and 5 per cent of low-pressure capacity were allowed for outages of equipment in these two categories.

In order to simplify the calculations of annual fuel costs, single heat rates therefore were used for both groups of high-pressure equipment. Refinements involving the use of heat rates at partial loads are not justified by the relatively short durations at these loads. Heat rates for existing high-pressure units vary between a minimum of 9,700 and a maximum of 12,500 Btu per kwhr. A weighted average of 11,200 Btu per kwhr was used. In the case of

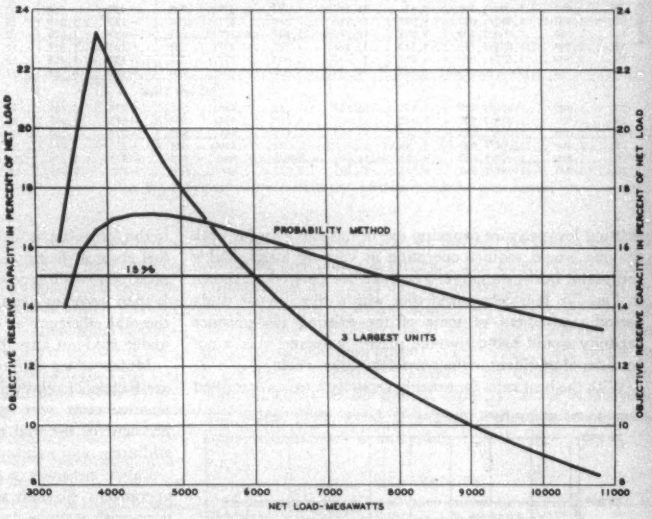

Fig. 5. Objective reserve-capacity requirements for additions of 300-mw units

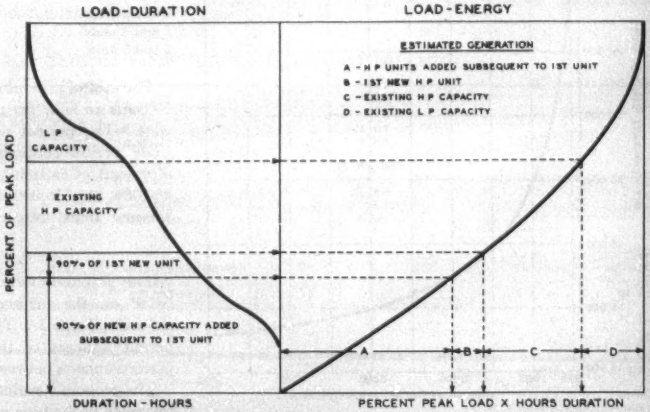
LOAD-DURATION
LOAD-ENERGY
ESTIMATED GENERATION
A - H P UNITS ADDED SUBSEQUENT TO 1ST UNIT
B - 1ST NEW H P UNIT
C - EXISTING H P CAPACITY
D - EXISTING L P CAPACITY
PERCENT OF PEAK LOAD
L P CAPACITY
EXISTING H P CAPACITY
90% OF 1ST NEW UNIT
90% OF NEW H P CAPACITY ADDED SUBSEQUENT TO 1ST UNIT
A
B
C
D
DURATION - HOURS
PERCENT PEAK LOAD X HOURS DURATION

Fig. 6. Use of load-duration and load-energy curves to obtain annual generation

Table I. Summary of Economic Comparison of Proposed Unit Additions

Proposal Number	Pressure, psi	Temperature, F	Station Net Heat Rate, Btu/Kwhr	Annual Fixed Charges	Differential Investment Justified, $1,000 Based on Annual Operating Costs: Fuel	Labor	Maintenance	Spinning Capacity	Total	Total Differential Investment	Investment, $1,000: Total Justified	Actual Required	Savings: Total $1,000	Dollars per Kw
180 Mw Units														
1	1,800	1,000/1,000	9,481	(Base for comparison)							36,000	36,000		
2	1,800	1,000/1,000	9,444	None	131	None	13	None	144	144	36,144	36,395	−251	−1.39
3	1,800	1,050/1,000	9,378	None	365	None	37	None	402	402	36,402	36,676	−274	−1.52
4	1,800	1,000/1,000	9,432	None	174	None	17	None	191	191	36,191	36,734	−543	−3.02
5	2,000	1,050/1,000	9,318	None	577	None	58	None	635	635	36,635	36,894	−259	−1.44
6	1,800	1,000/1,000	9,444	None	131	None	13	None	144	144	36,144	37,039	−895	−4.97
7	1,800	1,050/1,050	9,318	None	577	None	58	None	635	635	36,635	37,232	−597	−3.32
8	2,000	1,050/1,050	9,257	None	794	None	79	None	873	873	36,873	37,417	−544	−3.02
250 Mw Units														
9	1,800	1,000/1,000	9,436	11,146	504	277	220	−137	864	12,010	48,010	46,553	1,457	5.83
10	1,800	1,050/1,000	9,372	11,146	815	277	252	−137	1,207	12,353	48,353	46,809	1,544	6.18
11	2,000	1,050/1,000	9,312	11,146	1,107	277	281	−137	1,528	12,674	48,674	46,944	1,730	6.92
12	1,800	1,050/1,050	9,312	11,146	1,107	277	281	−137	1,528	12,674	48,674	47,515	1,159	4.64
13	2,000	1,050/1,050	9,251	11,146	1,403	277	310	−137	1,853	12,999	48,999	47,720	1,279	5.12
14	4,500	1,150/1,100/1,100	8,442	11,146	5,337	277	704	−137	6,181	17,327	53,327	53,602	−275	−1.10
300 Mw Units														
15	1,800	1,000/1,000	9,406	18,563	1,745	454	562	−272	2,489	21,052	57,052	53,846	3,206	10.69
16	1,800	1,050/1,000	9,342	18,563	2,118	454	599	−272	2,899	21,462	57,462	54,145	3,317	11.06
17	2,000	1,050/1,000	9,281	18,563	2,473	454	635	−272	3,290	21,853	57,853	54,417	3,436	11.45
18	2,400	1,050/1,000	9,190	18,563	3,003	454	688	−272	3,873	22,436	58,436	54,586	3,850	12.83
19	1,800	1,050/1,050	9,281	18,563	2,473	454	635	−272	3,290	21,853	57,853	54,889	2,964	9.88
20	2,000	1,050/1,050	9,221	18,563	2,823	454	670	−272	3,675	22,238	58,238	55,161	3,077	10.26

existing low-pressure capacity, use of this capacity for peak shaving would require operation at varying loads, and a composite heat-rate curve was therefore derived as shown in Fig. 7. It is recognized that within the 50-year study period, retirement of some of the existing low-pressure capacity would probably take place; however, this is not considered pertinent to the purposes of this article.

With the heat rates for existing capacity fixed as described in the foregoing, it was possible to express the system annual fuel costs as present-worth values in terms of heat rate applicable to each type of unit addition included in the study. It then becomes a simple matter to evaluate differentials in thermal efficiency as estimated for the different proposals under study at any appropriate fuel price.

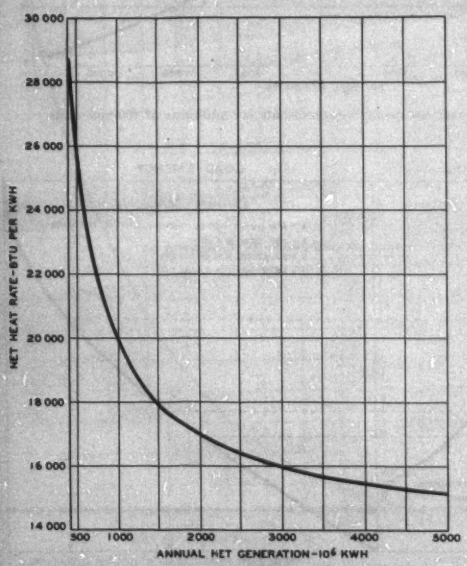

Fig. 7. Heat rate for existing low-pressure capacity

Maintenance differentials are difficult to estimate, and are factors of relatively little weight. Accordingly, maintenance costs were assumed to represent 10, 15, and 20 per cent of the fuel costs for new high-pressure capacity additions, and existing high- and low-pressure capacities.

Labor costs are a function of the number of units in operation. Six-unit stations were assumed for new additions with stations designed to require the same operating personnel for pairs of units. Based on current experience, annual labor costs were estimated as:

1 and 2 units	$400,000
3 and 4 units	$550,000
5 and 6 units	$720,000

The cost of providing spinning capacity was estimated at 30 cents an hour per megawatt or $2,628 a year per megawatt. The present worth per megawatt for the 50-year study period becomes 15.762 × $2,628 or $41,422 per megawatt of capacity, giving present-worth values of $7,456,000, $10,356,000, and $12,427,000 for the 180-, 250- and 300-mw units, respectively.

CONCLUSIONS

THE ECONOMIC EVALUATION of the 20 proposals studied, based on the methods and assumptions described, are shown in Table I. The table is arranged by unit sizes, to permit analysis of the effect of differences in thermal performance as between units of equal capacity.

The economic evaluation of each proposal was made with reference to the base proposal, by comparison of the difference between the investment that can be justified by

differentials in annual fixed charges and operating costs, and the actual investment required, converted to a savings in investment per kilowatt of capacity. This method of comparison differs from the conventional methods recommended in available textbooks on the subject of engineering economy. It is preferred because it permits a breakdown into components for analysis of relative influence of annual fixed charges and operating costs for the exercise of judgment in the selection of the initial unit addition.

Insofar as the system under study is concerned, the results shown in Table I indicate the economic choice to be a 300-mw unit. The margin in favor of this size unit is wide enough to assure proper choice in light of estimating errors and lack of refinements in the calculations. The economic justification for the selection of a 300-mw unit has been influenced in part by the absence of material differential investments for transmission facilities. Under other circumstances this could be criterion for selection of smaller units.

The savings in annual fixed charges, which the 250- and 300-mw-unit additions effect, represent from 83 to 93 per cent of the total differential investments justified.

In view of the announcement of two installations on order for operation at supercritical pressures, the economic evaluation of such an installation has been included in Table I as proposal number 14. It is of interest to note that the estimated investment for such an installation exceeds the amount that could be justified.

Although it was assumed that identical units would be added during the 50-year study period, it is recognized that the initial unit would lose its loading preference as units would be added to the system. The effect of size on the utilization of the initial unit for generation, as reflected by its annual capacity factor, is illustrated in Fig. 8. During the first 6 to 9 years of service, it would be possible to operate the units at maximum output. Thereafter, there would be a reduction in output. There is no indication of any material effect on the annual capacity factors as between unit sizes. The trend is a slight reduction in capacity factor with increase in unit size.

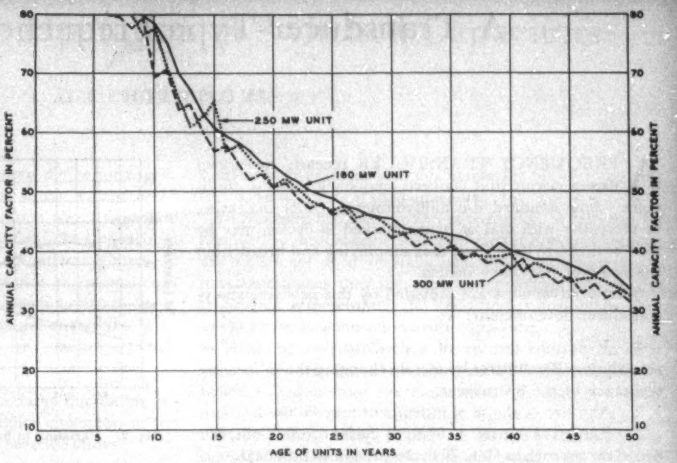

Fig. 8. Effect of size on utilization of initial unit for generation

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2. Economy of Large Generating Units, H. P. Seelye, W. W. Brown. *Proceedings*, American Power Conference, vol. 16, 1954, pp. 182–8.

3. Seventeenth Semi-Annual Electric Power Survey, April 1955. *Publication*, Edison Electric Institute, no. 55-5.

Appendix I. Sample Calculation of Justified Investment

Proposal number	1 (base)	17
Unit capacity, mw	180	300
Estimated actual investment, $1,000	36,000	54,417
Heat rate (*R*), Btu/kwhr	9,481	9,281
Present-worth values (in thousands of dollars)		
Annual fixed charges	$27.674,879I'$	$18.259,548I'''$
Fuel	$828,231+98.0839R'$	$725,901+106.3570R'''$
Labor	30,598	22,304
Maintenance	$131,816+9.8084R'$	$114,510+10.6357R'''$
Spinning capacity	7,456	12,427

Differential investments justified by annual savings		In Thousands	Per Cent of Total
Fixed charges	$18.259,548I''' = 27.674,879\ (36,000)$		
	$I''' = 54,563$		
	$dI''' = 54,563 - 36,000$	$18,563	84.9
Fuel	$18.259,548\ (dI''') = [828,231 + 98.0839\ (9,481)] - [725,901 + 106.3570\ (9,281)]$		
	$dI''' =$	2,473	11.3
Labor	$18.259,548\ (dI''') = 30,598 - 22,304$		
	$dI''' =$	454	2.1
Maintenance	$18.259,548\ (dI''') = [131,816 + 9.8084\ (9,481)] - [114,510 + 10.6357\ (9,281)]$		
	$dI''' =$	635	2.9
Spinning capacity	$18.259,548\ (dI''') = 7,456 - 12,427$		
	$dI''' =$	−272	−1.2
Total		$21,853	100.0

A Transducer-Type Frequency Meter

U. L. SMITH

A FREQUENCY TRANSDUCER recently developed uses a circuit that converts frequency into d-c millivolts. Any standard d-c millivoltmeter, either indicating or recording with dial or paper marked in cycles, may be used to measure its output, thus simplifying and broadening the scope of frequency meters.

Several advantages are provided by this new frequency-transducer development:

1. It permits the use of a standard d-c indicating or recording millivoltmeter by merely changing the calibrating resistance of the instrument.
2. Any size or shape of instrument may be used.
3. Ranges as narrow as 59 to 61 cycles can be built, but broad ranges such as 50 to 70 cycles are just as practical.
4. The transducer can be furnished for any basic frequency, such as 50, 60, or 400 cycles.
5. Only one size and type of transducer is needed.
6. The scale is nearly uniform over the entire range.
7. It eliminates the necessity of tooling, building, and stocking of mechanisms that are used only for frequency meters.

The circuit shown in Fig. 1 uses two off-resonance parallel circuits. Each of these contains resistance, inductance, and capacitance in series. The capacitances are 0.10 and 0.15 microfarad, and the inductances are 30 to 80 henrys adjustable. For a frequency range of 55–60–65 cycles, the inductance in circuit *1* is adjusted to give resonance at approximately 48 cycles. The inductance in circuit *2* is adjusted to give resonance at approximately 72 cycles. The current–frequency relation is shown in Fig. 2. The I_1 and I_2 currents in these two circuits pass through the r resistors, the ring-type rectifier, and the R_1 and R_2 resistors. The d-c millivoltmeter is connected across points X_1 and X_2. The R_1 and R_2 resistors are the calibrated resistors, and the voltage drop across them determines the output of the transducer.

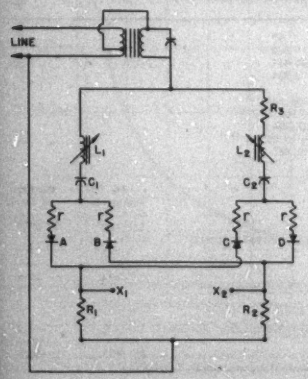

Fig. 1. Frequency-transducer circuit

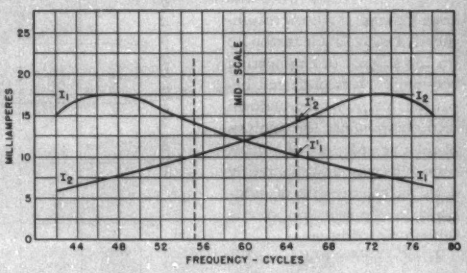

Fig. 2. Variation in branch currents with frequency change

At 60 cycles, the currents I_1 and I_2 are equal, so there is no d-c voltage across points X_1 and X_2. For a frequency of 65 cycles, the I_1 current decreases to I_1' and the I_2 current increases to I_2'. Because of the rectifiers, there will be a d-c potential across X_1X_2, and X_2 will be positive with respect to X_1. At 55 cycles, the reverse condition exists, and X_1 will be positive with respect to X_2. A center-zero millivoltmeter connected with its plus terminal to the X_2 point and its negative terminal to the X_1 point will read zero at the 60-cycle balance point and will read up-scale for 65 cycles and down-scale for 55 cycles. Its deflection is proportional to the difference between I_1 and I_2 and is nearly proportional to frequency.

Different frequency ranges are obtained by using millivoltmeters with different ranges. For a 50–60–70 range, a center-zero d-c instrument with a sensitivity of about 6,000 ohms and 0.5 milliamperes is used. For other ranges, different values of resistance are used. Calibration is obtained by adjusting the millivoltmeter resistance to match the output of the transducer.

A saturation-type voltage regulator is used to hold a constant voltage across the circuit for variation of line voltages of 100 to 130 volts.

This frequency transducer provides a new means of measuring frequency with performance well within the requirements of American Standards Association's standards. It has the advantage that a basic unit can be calibrated with standard d-c instruments. Even for small panel boards the frequency meter can be made to match, in size and shape, the rest of the instruments. It can be built with narrow frequency ranges for close frequency control or with wider frequency ranges for general use.

Digest of paper 55-485, "A Transducer-Type Frequency Meter," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentations at the Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Published in AIEE *Transactions*, vol. 74, pt. I, 1955, pp. 497–500.

U. L. Smith is with Westinghouse Electric Corporation, Newark, N. J.

Report on the Operation of Switched Capacitors

AIEE COMMITTEE REPORT

PREVIOUS AIEE REPORTS covered the performance, operation, and maintenance of shunt capacitors.[1,2] These reports contained little information about capacitor switching. In recent years, the use of switched capacitors has increased. This report has been formulated to provide a resume of existing literature and known experience concerning the factors to be considered in such applications.

The fundamental reason for switching capacitors is to improve system performance. This involves some of the following specific reasons:

1. Several types of load can place large fluctuating reactive demands on the system. Switched capacitors at the load and on the lines can supply the reactive kilovar.
2. Switching permits the use of capacitors as large as needed during peak load periods without the objection of excessive boost in light load voltages.
3. It may be necessary to switch capacitors to avoid abnormally low excitation on the system generators.
4. It may be necessary to switch capacitors to minimize I^2R and I^2X transmission line losses.
5. The installation of switched capacitors may provide an emergency voltage boost until permanent corrective measures can be taken.
6. Maximum utilization of the capacity of power equipment may require use of capacitors during heavy load to reduce current loadings by improving the power factor.

Capacitor switching equipment usually consists of breakers or switches such as are used for fault and/or load interruption on transmission and distribution circuits. Some of the commonly used types are indoor air and oil circuit breakers, outdoor circuit breakers, oil switches, and loadbreak switches.

The switching of capacitor circuits presents problems not encountered in the usual load-switching application. When a capacitor bank is energized, a comparatively large inrush current can flow into the bank. At the moment of circuit closing, the completely uncharged capacitor represents a short circuit to the system and the inrush current to the capacitor bank is limited only by the impedance of the circuit supplying the bank.

When two or more steps of the bank are switched independently, that is, when an adjacent bank is already energized, a very high inrush current can occur. Nearly all of the inrush current is supplied by the charged capacitor bank. The maximum inrush current occurs when the switch is closed at voltage peak.

The opening of a capacitor circuit presents additional problems. In some types of switching equipments, travel of the movable contact may not be fast enough to insure sufficient dielectric strength across the open contacts after one-half cycle. The circuit will then restrike, causing high oscillatory currents to flow between the banks and extremely high voltages to occur across the breaker contacts and to be trapped on the capacitors.

In practice, the interruption of capacitor circuits can be handled by most modern standard circuit breakers without the occurrence of abnormally high voltages. However, it is recommended that the capacitor manufacturer or the switchgear representative be consulted regarding breaker applications in connection with capacitors.

Many types of intelligence are used to control capacitor banks. The selection of a method should be based upon the benefits desired from the capacitors. Voltage is a commonly used signal for controlling capacitor switching. A contact-making voltmeter having suitable characteristics is used to initiate the switching operation. In addition, time delay may be incorporated in the control circuit to prevent excessive operation of the switching equipment.

Time is often used as intelligence for switching capacitors to the extent that a regular time cycle can fit in the curve of total reactive load.

Current control is often employed for use on regulated circuits where voltage is not a satisfactory signal for capacitor switching and where load variations do not cause inconsistent change in load power factor.

A kilovar control is best suited when it is desired to keep the kilovar supply on a given line within certain limits in order to reduce system losses and voltage drop and to release generating and transmission capacity.

Power-factor control is not a very satisfactory means for controlling switched capacitors because this method would cause pumping at light load and low power factor unless desensitizing auxiliaries are used. The same result can usually be obtained better with kilovar or current control.

If it is important to keep the voltage constant (within the limits of the bandwidth) at a point remote from the capacitor installation, line-drop compensation can be applied to the control equipment for switching the capacitors.

Current, time, or kilovar controls provide the proper types of intelligence for switching capacitors on voltage-regulated feeders. Voltage-controlled capacitors may be applied at the end of a regulated feeder circuit provided line-drop compensation is not used, or only the resistance settings of the compensator are used.

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1. Report of a Survey on the Performance of Shunt Capacitors, **AIEE Committee Report.** AIEE *Transactions*, vol. 68, pt. II, 1949, pp. 1200–07.

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Digest of paper 55-710, recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

This paper was prepared by the AIEE Capacitor Subcommittee of the AIEE Committee on Transmission and Distribution.

The personnel of the AIEE Capacitor Subcommittee are: **B. H. Schultz**, *chairman*, **R. M. Butler, W. C. Fowler, K. E. Hapgood,** and **L. T. Williams.**

Stability Characteristics of Molybdenum Permalloy Powder Cores

C. D. OWENS

Recent circuit emphasis on maximum stability and precision and minimum size has extended the use of molybdenum permalloy powder cores, originally designed for telephone circuits, to a wide variety of applications. Intrinsic properties and basic behavior, as well as design considerations, of the cores are discussed.

CORES of compressed molybdenum permalloy powder[1] have been in use for nearly 20 years in loading coils, filter coils, and transformers at voice and carrier frequencies in the telephone plant. They were developed by the Bell Telephone Laboratories and the Western Electric Company specifically for these applications, and have given highly reliable and satisfactory operations. During the past several years, the use of such cores has been extended to many industrial and military circuits, with emphasis on miniature size and high precision and stability. The stability of permeability and core losses with time, temperature, and flux levels are of particular importance to apparatus and circuit engineers. It is the purpose of this article to discuss the inherent stability characteristics of molybdenum permalloy powder cores and the apparatus design factors which affect the stability, on the basis of experience from telephone applications.

Molybdenum permalloy powder [2 Molybdenum (Mo)–82 Nickel (Ni)–16 Iron (Fe)] is made by grinding hot rolled and embrittled cast ingots. The material is screened to a fineness of 120 mesh for use in voice-frequency applications, and 400 mesh for use at higher frequencies. After the powder is softened by annealing, it is then thoroughly mixed with a water slurry of finely divided clay and other refractory materials. The mixture is dried by heating, which leaves a thin coating on the magnetic particles. This insulated powder is pressed into cores, usually ring shaped, in steel dies at pressures of 100 tons or more per square inch. The cores are heat treated at a temperature of 1,200 F in hydrogen to relieve strains in the magnetic particles caused by the pressing operation. Core permeabilities of 125, 60, 26, and 14 have been standardized. Typical examples of cores are shown in Fig. 1.

The Western Electric Company started manufacture of 125-permeability cores for loading coils in 1937, and has produced more than 20-million cores for this purpose alone. A baked enamel finish to serve as electrical insulation between the core and the winding was developed. The lower permeability cores (60, 26, and 14) using 400-mesh powder were developed for carrier-frequency filters and networks in which precise stable inductances were required. A means of neutralizing the normally positive permeability–temperature coefficient of the cores over certain temperature ranges by blending in a low Curie-point powder was worked out. In order to minimize the effects of impregnating wax and potting compounds on the permeability–temperature coefficient, a wax-tight varnish finish was applied.

The intrinsic properties and basic behavior of molybdenum permalloy powder cores will be considered in the following sections.

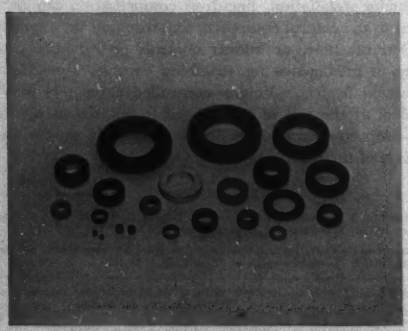


Fig. 1. Molybdenum permalloy powder cores for telephone use. The largest rings shown are 4 inches in diameter.

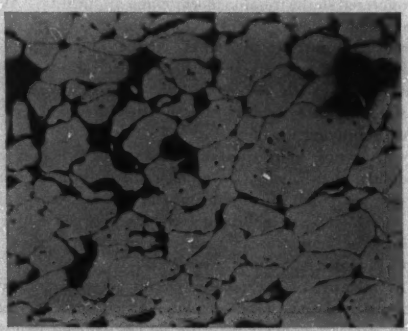


Fig. 2. Photomicrograph of a section of a 125-permeability core

AIR-GAP STRUCTURE IN POWDER CORES

THE PHYSICAL STRUCTURE of the core consists of particles of magnetic material separated by thin films of ceramic-type insulation.

Fig. 2 is a photomicrograph of a section of a 125-permeability core. Because of the high forming pressures, the surfaces of the permalloy particles are forced into a high degree of conformity. The larger dark areas are holes, where permalloy particles were dislodged in the polishing of the specimen. The insulation films between particles serve as air gaps in the magnetic circuit. For analytical purposes, the distributed air gaps may be assumed to be concentrated in one discrete air gap, as shown in Fig. 3. This assumption neglects fringing and nonuniform flux distribution in the permalloy particles which may arise from irregular shapes of the particles.

From the well-known magnetic circuit relationships, the effective core permeability μ_e can be expressed in terms of the permeability μ of the magnetic particles, and of the ratio r of the length of the flux path l_a through the air gaps to the length of the total magnetic circuit l_c, thus

$$\mu_e = \frac{\mu}{r(\mu-1)+1} \tag{1}$$

If μ_e is plotted against μ for various values of r, the curves shown in Fig. 4 are obtained. It will be observed that the core permeability μ_e approaches a limiting value, equal to $1/r$, for sufficiently high values of particle permeability μ. As this condition is approached, the core permeability is determined almost entirely by the amount of air gap, and is little affected by changes in particle permeability.

The relationships observed from Fig. 4 can be verified by computing the differentials of equation 1, thus

$$\frac{d\mu_e}{\mu_e} = \frac{dr}{r}\,\frac{-r(\mu-1)}{r(\mu-1)+1} = \frac{dr}{r}\left\{\frac{\mu_e}{\mu}-1\right\} \tag{2}$$

$$\frac{d\mu_e}{\mu_e} = \frac{d\mu}{\mu}\,\frac{1-r}{r(\mu-1)+1} = \frac{d\mu}{\mu}\,\frac{\mu_e}{\mu}(1-r) \tag{3}$$

Equation 2 relates the percentage change in core permeability with the percentage change in air gap, while equation 3 shows the relative percentage changes of core permeability and particle permeability. The intrinsic permeability of the magnetic particles is 1,000 or greater. In a 14-permeability core the coefficient of dr/r in equation 2 is 0.99, while the coefficient of $d\mu/\mu$ in equation 3 is 0.013. For the 125-permeability core the coefficients are 0.88 and 0.12, respectively.

Since the core permeability is so strongly dependent upon the air-gap length, all ambient conditions which may cause swelling or shrinking of the insulating materials must be examined critically. These conditions include humidity, temperature, external pressure, and wax absorption.

In the case of the 125-permeability core, the insulation films comprise about 0.8 per cent of the length of the flux path. Since the average particle diameter is approximately 40 microns, the mean thickness of the insulation between particles is computed to be only about 0.32 microns. Much development effort went into working out a practical procedure for efficiently coating fine particles to yield permeabilities greater than 100. The insulation films must be capable of withstanding the high pressure involved in forming the cores and also a heat treatment of sufficiently high temperature to develop good magnetic properties in the permalloy particles.

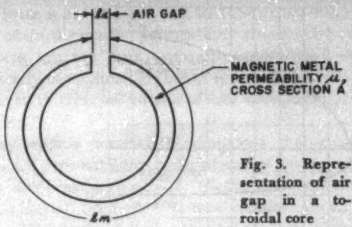


Fig. 3. Representation of air gap in a toroidal core

Total flux path in core: length $l_c = l_m + l_a$ Effective core permeability μ_c: $\frac{l_c}{\mu_c A} = \frac{l_m}{\mu A} + \frac{l_a}{A}$; $\mu_c = \frac{\mu l_c}{(l_m + \mu l_a)} = \frac{\mu}{[r(\mu-1)+1]}$; where: $r = \frac{l_a}{l_c} = \frac{\text{length of air gap}}{\text{length of magnetic material}}$

EFFECTS OF MOISTURE ON PERMEABILITY

DATA ARE SHOWN in Fig. 5 to illustrate that dry insulation absorbs moisture and that dry cores exposed to humidity undergo decreases in permeability. Evidently, as the insulation films absorb moisture, they expand and increase the air gap. On the other hand, laboratory tests carried out over a period of nearly 20 years indicate that

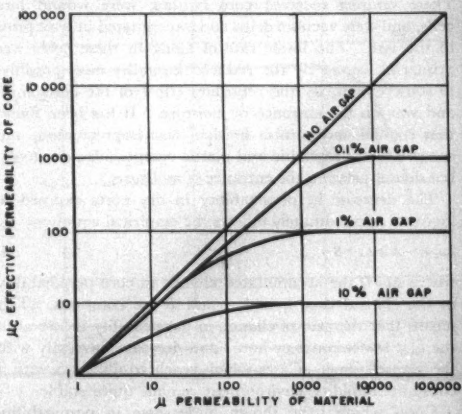


Fig. 4. Variation of effective permeability of a core containing an air gap with permeability of the core material

Text of a paper in special publication T-78 recommended by the AIEE Magnetics Subcommittee of the Committee on Basic Sciences and presented before the Conference on Magnetism and Magnetic Materials, Pittsburgh, Pa., June 14-16, 1955.

C. D. Owens is with Bell Telephone Laboratories, Murray Hill, N. J.

This paper covers work shared by numerous individuals in the Bell Telephone Laboratories and the Western Electric Company. The study on moisture absorption by the dry insulation was made by W. Hartmann. The photomicrograph was made by E. E. Thomas. The author is indebted to A. G. Gans, V. E. Legg, H. L. B. Gould, S. G. Hale, and J. F. Dillinger for guidance and suggestions in the preparation of the paper, and to F. J. Dempsey and Mrs. C. E. Hedden for assistance in measurements.

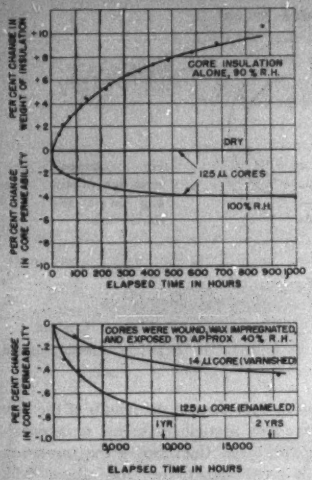


Fig. 5. Effects of moisture on weight of insulation and permeabilities of cores

cores which are maintained in a completely dry condition stay constant in permeability to within about ±0.1 per cent.

The insulation alone, after being dried by the standard core heat treatment of 1,200 F in hydrogen, absorbed about 10-per-cent moisture by weight at 90-per-cent relative humidity in 1,000 hours. A typical dry 125-permeability core exposed to 100-per-cent relative humidity for the same length of time showed a decrease in permeability of about 4 per cent. A 125-permeability core kept dry over a similar period showed no significant change in permeability. It will be observed from the lower curves that 14-permeability and 125-permeability cores exposed to a relative humidity of approximately 40 per cent prevailing in an air-conditioned laboratory room aged about 0.4 per cent and 0.8 per cent, respectively, in 2 years. These samples received core finishes, were wound into coils, and were vacuum dried and impregnated in wax prior to the test. The lower rate of aging in these cores was primarily caused by the reduced humidity and, possibly, to some extent, by the retarding effect of the core finish and wax on the entrance of moisture. It has been found that enamel and varnish finishes, wax impregnation, and encasement in asphaltic and plastic compounds slow down, but do not prevent, the entrance of moisture.

The decrease in permeability in dry cores exposed to moisture approximately follows the empirical equation

$$\Delta\mu_c = -A \log t + B \qquad (4)$$

where $\Delta\mu_c$ is the accumulated change in core permeability in the elapsed time t, and A and B are constants. This means that the rate of change in permeability is largest in the first few minutes or hours and decreases inversely with the elapsed time. Cores which reach equilibrium with a constant humidity environment remain quite stable.

Cores which have shown a decrease in permeability because of exposure to humidity may be restored substantially to the original dry-core value by redrying, requiring up to 48 hours of drying at 240 F under a vacuum of less than a centimeter to remove the moisture.

EFFECT OF TEMPERATURE CHANGES

Changes in core permeability with temperature are partially explained in terms of the differential expansion and contraction of the metal and insulation. The higher expansion coefficient of the metal causes a compression of the insulation, resulting in an increase in core permeability. The permeability–temperature change of a typical unstabilized molybdenum permalloy powder core is about 1 per cent for a temperature change of 100 F. In certain cores for precision applications, this plus coefficient is compensated by the addition of a small amount of special molybdenum permalloy powder containing approximately 12-per-cent molybdenum to the regular powder before it is formed into cores. This alloy has a Curie point just above room temperature and, hence, exhibits a very rapid drop in permeability as the Curie temperature is approached. By the use of blended mixes of lots of stabilizer with slightly different compositions, compensation to hold the permeability within ±0.1 per cent over a temperature range of 30 to 130 F has been made available in molybdenum permalloy powder cores for telephone applications. Compensation over wider temperature ranges is possible by the same method. Typical permeability–temperature curves for stabilized and unstabilized cores are shown in Fig. 6.

The change in air gap and core permeability, caused by differential expansion of metal and insulation, has been compensated for experimentally in low-permeability cores by the addition of fillers with a high coefficient of expansion, such as powdered fluorspar. Such materials are less efficient as insulation than the standard insulation developed for molybdenum permalloy powder cores and have not been applied commercially.

EFFECT OF WAXES

If unvarnished cores are soaked or impregnated with wax or potting compounds, such as asphalt, the insulation films show a large expansion with increasing temperature and produce a negative permeability–temperature coefficient. These changes are very unstable because of a

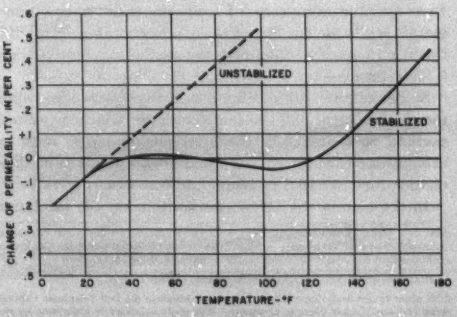


Fig. 6. Variation of permeability with temperature of stabilized and unstabilized molybdenum permalloy powder cores

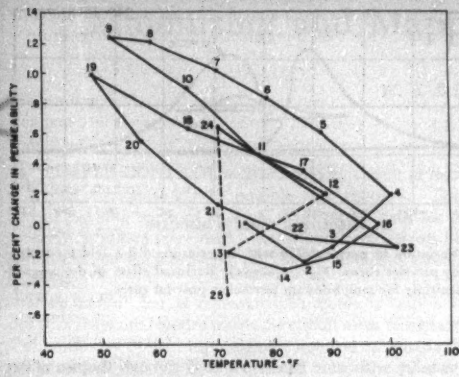


Fig. 7. Typical behavior pattern of a core impregnated in wax and then temperature cycled. The numbers indicate the sequence of measurements. The sequences 1–12 and 13–24 represent about 8 hours each. The dotted lines represent at least 16 hours between points

time-dependent cold flow characteristic of the wax compound, as shown in Fig. 7. The permeability will continue to drift each time the temperature is changed. The pattern shown in Fig. 7 depends not only on the temperatures, but also on the elapsed time at each temperature.

MECHANICAL EFFECTS

If external pressures are applied to powder cores, an increase in permeability will result when the insulation films are compressed. The contraction of enamel, varnish, plastic, or other encasing compound during curing may exert sufficient pressure to change the permeability. This is especially true for very small cores, where the surface area is large compared to the core volume. Such cores normally show a more negative permeability–temperature coefficient because of the variation of pressure with temperature. Under some conditions, the temperature coefficient may be nonlinear and may show some degree of nontracking when the cores are cycled. Care must be taken to eliminate moisture effects during the measurement of temperature coefficients.

The tensile strength of 125-permeability material is over 200 pounds per square inch of cross section. Under some conditions, toroids of small cross section may be broken because high-speed winding machines apply a torque or develop a tensile force by the wedging action of turns of wire pulled between those already applied. Insulating enamel on the core increases the tensile strength.

EFFECT OF FLUX DENSITY ON PERMEABILITY

The permeabilities of molybdenum permalloy powder cores increase with increasing a-c flux density up to about 1,000 gausses (average density in the core cross section), and then decline more and more sharply until saturation is reached at about 6,000 gausses, as shown on Fig. 8. The total increase is about 2 per cent in 125-permeability cores. Because of the decreasing permeability above 1,000 gausses, these cores are not used ordinarily above that density. The majority of applications are at flux densities well under 100 gausses to take advantage of low core losses and low modulation.

It may appear somewhat anomalous that maximum powder-core permeabilities occur at such a low flux density, whereas the peak permeability of the molybdenum permalloy material occurs at a flux density above 5,000 gausses. The much lower peak in the powdered core arises from the nonuniform distribution of flux in the particle. The flux density increases much more rapidly in points or adjacent areas of the magnetic particles, causing them to saturate at a lower magnetizing field than is required to saturate the entire cross section of the core.

Cores subjected to d-c magnetization show a decrease in permeability because of the large decrease in permeability effected in the magnetic particles. The permeability of a 125-permeability core will drop about 30 per cent for a superimposed field of 30 oersteds as illustrated in Fig. 9.

After saturation with direct current, an average residual effect of the order of 0.1 per cent occurs in 125-permeability cores and 0.02 per cent in 14-permeability cores, as shown in Fig. 10. The usual manufacturing limits are ±0.5 and ±0.1 per cent, respectively.

CORE LOSSES

Core losses in powder cores are adequately described in terms of eddy current, hysteresis, and residual losses.[3] These are functions of frequency and flux density. Eddy-current losses decrease slightly with increasing temperature because of the increase in resistivity of the metal particles. Hysteresis and residual losses are insensitive to normal temperature variations, particularly as compared to the variation in d-c resistance of copper wire used in the windings.

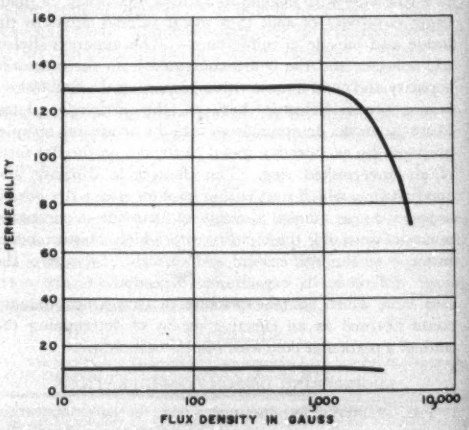
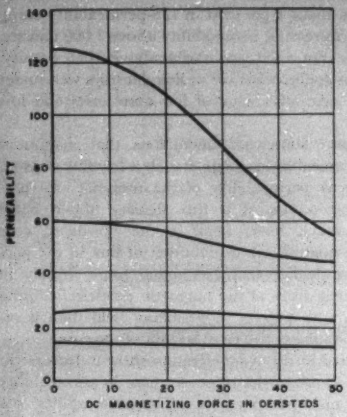


Fig. 8. Variation of permeability with flux density for molybdenum permalloy powder cores



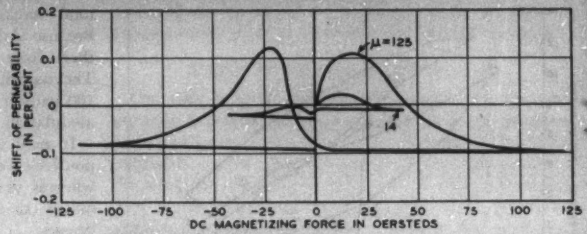


Fig. 9 (left). Variation in permeability with superimposed d-c field for molybdenum permalloy powder cores. Fig. 10 (above). Residual effect of d-c magnetization on permeability for molybdenum permalloy powder cores

DIELECTRIC PROPERTIES

If a low-permeability core is wound to an inductance of 40 millihenries for operation at 100 kc, dielectric losses shunting the high impedance may substantially reduce the Q of the inductor. Dielectric losses large enough to be troublesome may arise in a core which has absorbed moisture. The "apparent" dielectric constant of the metal-insulation body is of the order of 100 for dry 14- and 26-permeability cores and much higher in 125-permeability cores. The dielectric Q in a thoroughly dry 14-permeability core at 100 kc is usually above 130, but may drop to less than 10 if the core is exposed to a relative humidity exceeding 50 per cent for several weeks. The dielectric constant increases 10 to 15 times as the core absorbs moisture.

Comparative measurements on the dielectric properties of a ring core with enamel or varnish finish may be made using electrodes of split thin metal tubings fitted to the inside and outside circumferences. The apparent dielectric constant and the Q are computed from the measured capacity and conductance values, assuming the core to be a homogeneous dielectric between the electrode plates. More accurate determinations can be made on samples prepared by evaporating metal electrodes on the flat faces of an unvarnished ring. The changes in capacity and conductance, which start within minutes after a dry core is exposed to a humid atmosphere, provide a dramatic means of detecting the rapidity with which moisture penetrates, even through enamel and varnish. Because of the large difference in capacitance measured on dry cores and those which contain moisture, dielectric measurement could be used as an effective means of determining the state of a particular core with respect to moisture.

ENGINEERING DESIGN CONSIDERATIONS

The stability requirements, size of core, operating conditions, and many other factors enter into the design considerations for inductors and transformers on molybdenum permalloy powder cores. The high intrinsic stability with time can be realized through the use of dry hermetically sealed cores free of large strains from windings and free of impregnating or potting compounds. One method has been to support the wound coil mechanically in a metal can, then thoroughly vacuum dry through a small hole in the can, and solder a plate over the hole. When small cores are used, some advantage may be gained by omitting the enamel or varnish, and providing other electrical insulation, such as a fabric wrapping, over the core. Many applications have not required the highest possible degree of precision in the past and, hence, engineering designs usually have not incorporated all of these precautions. The practical importance of aging stability must be balanced against other expected changes from variations in temperature, flux density, or superimposed d-c conditions, previously discussed. In many precision applications, low core losses and low modulation are of prime importance.

CONCLUSION

The techniques of manufacture and application for molybdenum permalloy powder cores have been developed and improved in the Bell Telephone Laboratories and the Western Electric Company over a period of years. The cores have given reliable operation in extensive telephone applications and other uses. The developing trends toward miniature sizes and maximum precision and stability in a wide variety of circuit applications have emphasized the need for reviewing the stability behavior of the cores and considering means of best utilizing them.

The molybdenum permalloy powder core, consisting of annealed compacts of fine magnetic particles separated by ceramic-type insulation films, basically possesses a high degree of chemical and magnetic stability. When the best stability of core permeability is desired for precision apparatus, the insulation films should be kept free of moisture, wax or potting compounds, and should not be subjected to large mechanical stresses.

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2. Measurements at Low Flux Densities Using the A-C Bridge, **V. E. Legg.** *Bell System Technical Journal*, New York, N. Y., vol. 15, January 1936, pp. 39–62.

Minimizing and Mapping Sequential Circuits

W. S. BENNETT

A SIMPLE CONTROL and/or memory circuit of four coils represents $2^4=16$ possible combinations. The mental juggling required to keep these sorted calls for a properly organized score card. Relay requirements can be minimized and the score card, or "map," delineates circuit synthesis.

Minimization. Let M represent the number of combinational or sequential modes which the circuit must recognize. The number of distinct input signals, supplied externally, is designated E. If $M>E$, a sequential relay circuit is required to generate internal signals. If there are n relays, $2n$ additional modes are required to turn the relays on and off. The minimum is the least value of n to satisfy

$$2^n-2n\geq M-E \qquad (1)$$

"Minimization" is accomplished here by the number of coils, only. At present no technique is presented for the consideration of stepping relays, mechanical latches, etc.

Mapping the Circuit. Consider the following example: Two switches P,Q supply four inputs (0,0), (0,1), (1,1), (1,0); hence $E=4$. Device X is to operate on (1,1) if P closed first; Y is to operate if Q closed first. The four inputs, with this sequential distinction, mean that the circuit must recognize five modes: $M=5$. Equation 1 gives the requirement: $n=3$. Designating these relays A, B, and C, their eight possible combinations are represented by a map of the type proposed by Karnaugh.[1]

The development of the arrows in the map, Fig. 1, will be described, using the notation of Table I. $A'B'C'$, the upper left square, will be called the "rest" mode, Mode *1*, where all relays are de-energized. Anticipating that A may respond identically to P, and B to Q, the transition occurring when P is closed is shown as the arrow from Mode *1* to Mode *2*, $A'B'C'\rightarrow AB'C'$. If P is released, A will de-energize, returning the circuit to Mode *1*, so the arrow on Fig. 1 has heads on both ends; i.e., the transition is reversible. With P already pressed (and held) so the circuit is in Mode *2*, press Q. This operates B, causing the transition $AB'C'\leftrightarrow ABC'$. Mode *3* is required input to operate X.

If Q is closed first, let this cause C to be energized as well as B (so the final combination AB will be distinguished by C as opposed to C'). Entry from Mode *1* to $A'BC'$ is thus shown as a continuous arrow, going on into $A'BC$, Mode *4*. Mode *4* can also be entered from Mode *3*, as shown.

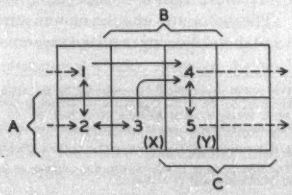

Fig. 1. Mapping a relay circuit. X = abc'; Y = abc

Table I. Switching Algebra Nomenclature

Capital letters = switches or relay coils; lower-case letters = contacts on corresponding relays.
a = normally open contact on A; a' = not a = normally closed contact on A.
1 = value of energized coil or closed contact (continuity); 0 = value of de-energized coil or open contact (no continuity); if $A=1$, $a=1$ and $a'=0$; if $A=0$, $a=0$ and $a'=1$.
$ab'=a$ and b' (contacts in series); $a+b'=a$ or b' (contacts in parallel).

Square $A'BC'$, entered from either direction, causes immediate transfer to $A'BC$. Square $A'BC'$ thus provides an internal signal, and will be called an "unstable" mode. As such, no arrowheads appear within it, and the arrows passing through it represent irreversible transitions.

It was known that five of the eight available squares were needed when the problem was originally stated. These were "stable" modes, of which four have been generated so far in the example. The fifth, ABC, is entered reversibly from Mode *4*, and operates Y, as shown by the dashed double-headed arrow on Fig. 1. The $n=3$ relays required $2n=6$ signals, of which $4(=E)$ were externally supplied. It could have been seen that $2n-E=6-4=2$ internal signals would be required. One of these, $A'BC'$, has been used already. The second may be used as either of the $B'C$ squares, to return Mode *4* to rest, or Mode *5* to Mode *2*. Note, however, that only seven modes have been prescribed. The eighth (whether $AB'C$ or $A'B'C$) is a "don't-care" mode, available if wanted. Using both remaining squares then, as in Fig. 1, the mapping operation is completed.

Circuit Equations. Since the identities $A=P$ and $B=Q$ were retained throughout, it is only necessary to find the equation for C. C must be energized by the unstable mode $A'BC'$, and held in BC (a 2-square subcube). Hence

$$C=a'bc'+bc \qquad (2)$$

Inspection of the map reveals that the first term may be included in the subcube $a'b$, overlapping bc, thus

$$C=a'b+bc=b(a'+c) \qquad (3)$$

Transfer-time difficulties (when all contact-pairs on a relay are open) need be checked only in unstable squares when a holding circuit is involved. There are no such situations in the present example. When they do occur, they should be checked by setting $r=r'=0$ (for $r\leftrightarrow r'$) and evaluating the holding circuit concerned.

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1. The Map Method for Synthesis of Combinational Logic Circuits, **M. Karnaugh**, AIEE *Transactions*, vol. 72, pt. I, November 1953, pp. 593–9.

Digest of paper 55-436, "Minimizing and Mapping Sequential Circuits," approved by the AIEE Committee on Communication Switching System and recommended by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27-July 1, 1955. Published in AIEE *Communication and Electronics*, September 1955, pp. 443–7.

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Thermal Evaluation of Enameled Magnet Wire

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MEMBER AIEE

The thermal life of an electrical insulating system made up of magnet wire, coated with a modified-silicone enamel and other silicone components, has been evaluated by three different test methods, which are in accordance with proposed AIEE Test Codes that have either received tentative approval or are under consideration.

A THREE-YEAR PROGRAM of work on the evaluation of a modified-silicone magnet wire enamel is summarized in this article. During this time, various groups within the AIEE have been working to develop more realistic and more reliable methods for evaluating the thermal stability of insulating materials and systems. As these AIEE test procedures developed, they were used to evaluate silicone insulating systems. The three test procedures of interest to be discussed are:

1. Test Procedure for Trial Use for Evaluation of the Thermal Stability of Enameled Magnet Wire, AIEE Standard Number *57*.
2. Test Code for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery, Part I, Motorettes, AIEE Standard Number *1C*.
3. Test Code for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery, Part II, Motor Tests (Proposed).

Fig. 1. Specimens used in thermal evaluation tests

The three types of test specimens—the magnet wire twist, the motorette, and the motor—are shown in Fig. 1.

Test results provide sufficient data for a comparison of the three methods. The correlation among the thermal life values of the silicone system as obtained by the three methods is excellent. This indicates that each of the test methods provides data that can be evaluated in terms of expected life. If such correlation can be obtained in evaluating other insulating systems, then the test methods will be excellent for evaluating any insulating material or system.

For example, in the preliminary stages of development, the dielectric twist test is useful in the selection of the best wire enamel. As work progresses, more elements of a system must be studied. In this phase, the motorettes may be most useful. As a final proof of the insulation system, the more extensive test should be made on the motors.

In this discussion, it is assumed that failure of the system is caused by thermal deterioration of the insulation. Failures that might be caused or influenced by mechanical defects, chemical contamination, voltage surges, etc., are not considered.

MATERIALS TESTED

COPPER MAGNET WIRE, number 18 American Wire Gauge (AWG), coated to a heavy build with Sylkyd *1360* or *1361* wire enamels was used in all tests. For the motorette and motor tests, this wire was obtained from a commercial wire manufacturer. Silicone varnish *997* was used to impregnate all dielectric twist specimens, motorettes, and motors.

Slot liners and phase separators used to complete the motorettes and the motors were commercial silicone resin bonded mica-glass components. Other insulation, such as sleeving, lead wire, and slot wedges, was conventional commercial Class *H* silicone materials.

The motorettes and the motors were wound by a local rewind shop following regular commercial winding procedures.

Full text of paper 56-133 recommended by the AIEE Committee on Dielectrics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

J. F. Dexter is with Dow Corning Corporation, Midland, Mich.

The author wishes to acknowledge the assistance of C. G. Currin, William McLean, C. W. Paxton, and F. A. Smith.

TEST PROCEDURES

Twist Test. Several years ago, a high-temperature modified-silicone bare magnet wire enamel was introduced by Dow Corning Corporation, Midland, Mich. During its development, laboratory evaluation was necessary to determine the relative thermal stability of a great number of formulations. Of necessity, a simple test method was developed using the National Electrical Manufacturers Association (NEMA) twisted-pair dielectric test. This early work, together with the many contributions by a task force under the sponsorship of the AIEE Subcommittee on Dielectric, resulted in the test procedure[1] now under consideration for publication as an AIEE Test Procedure.

The test consists of aging the dielectric twist specimens at various temperatures, and periodically subjecting them to a voltage stress. To make the test more realistic, the specimens are dipped in impregnating varnish. The various factors such as test voltage, humidity conditioning, and aging temperature that influence the test were described earlier.[1] The results were obtained by using the methods described in the proposed Test Procedure. At each of several temperatures, ten impregnated twist specimens were aged and periodically subjected to a voltage stress of 1,000 volts.

Motorette Tests. The motorette tests were made in accordance with the present issue of AIEE Standard Number *1C*, dated January 1954. The test voltages were 600 volts alternating current applied between phases and between each phase and ground (frame). The turn-to-turn test voltage was 120 volts alternating current. Ten motorettes were aged at each temperature.

A proposed revision of the AIEE Standard *1C* recommends a turn-to-turn test voltage of only 50 volts alternating current; however, the results of these tests indicate that the original 120-volt test is satisfactory. In any event, the test voltage selected should be a value that will assure good correlation between the magnet wire performance obtained in the motorettes and that obtained in motors.

As the test specimen is scaled down in relation to the actual equipment, it follows that failure criterion voltages should be scaled upward. This compensates for differences in area, spacial, and volume relationships and for the fact that full operating voltages are not applied continuously to the model. An excellent example of this fact is the twist test. In this method, the failure voltage is 1,000 volts alternating current, which is much higher than the turn-to-turn voltages in motors or that used in testing motorettes. However, by selecting a high voltage, the twist-test life values correlate with the life of motorettes wound with the same wire.

The motorettes were conditioned periodically for 3 days at 100-per-cent relative humidity. The humidity chamber was a sealed box containing a water pan kept at 10 C above room temperature. Under these conditions water condensed on the motorettes. An indication of water absorption was obtained by measuring insulation resistance. Fig. 2 shows the insulation resistance measured on 10 motorettes during the 3-day conditioning time. The measurements were made at 500 volts direct current between the windings and the frame. This was done without disturbing the motorettes in the humidity chamber. Curves are drawn through the values measured on two of the motorettes. The wide spread in insulation resistance should be noted.

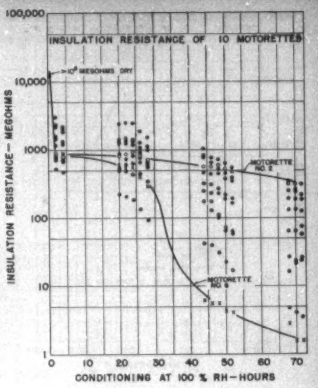


Fig. 2. Insulation resistance of 10 motorettes; conditioned at 100-per-cent relative humidity, aged 2,000 hours at 200 C

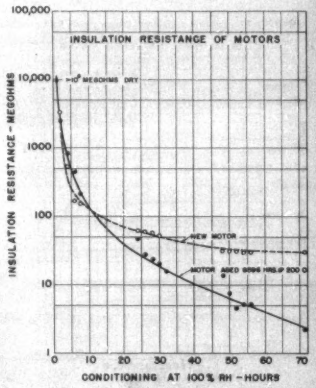
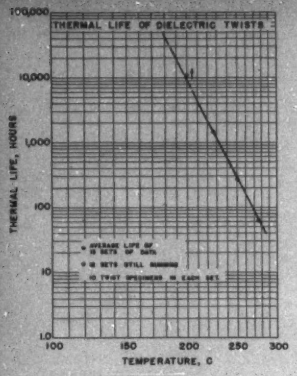


Fig. 3. Insulation resistance of silicone insulated motors; conditioned at 100-per-cent relative humidity

Motor Tests. The motors in this test program[3] were NEMA frame size *284* and were wound for operation at 440 volts, 3 phase, 60 cps, 1,150 rpm. The test motors are operated at normal line voltage of 440 volts for predetermined periods at the desired average copper temperature. Following each heat run, the motors are disassembled and placed in a tank maintained at 100-per-cent relative humidity. The motors are cooled to room temperature prior to placing in the tank so that water condenses on the insulation. The motors are conditioned for 24 hours.

Immediately upon removal from the conditioning tank, a 500-volt a-c test is applied for 1 minute between each phase and ground. Insulation resistance is measured, as well as dissipation factor and capacitance of the winding to ground. Following these tests the motor is reassembled



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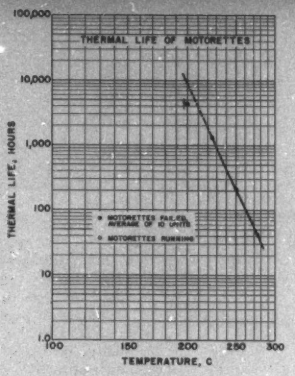

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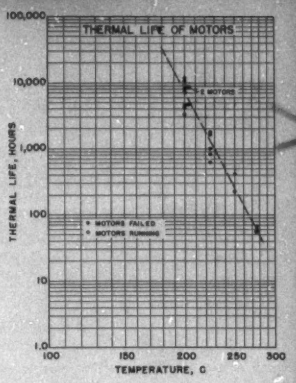

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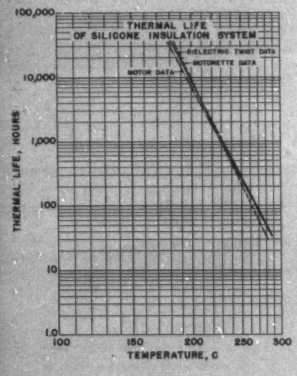

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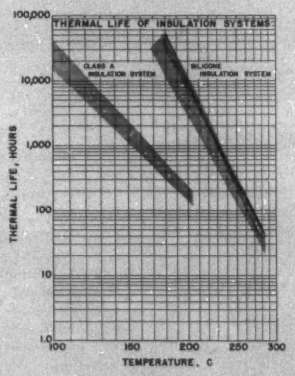

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Fig. 4. Thermal life of dielectric twist specimens made with Sylkyd enameled wire and varnish 997. Data from Table I. Fig. 5. Thermal life of motorettes wound with Sylkyd enameled wire and insulated with silicone components. Data from Table V. Fig. 6. Thermal life of motors wound with Sylkyd enameled wire and insulated with silicone components. Data from Table VII. Fig. 7. Thermal life of silicone-insulation system determined by three test methods. Data from Tables I, VI, VII. Fig. 8. Comparison of thermal life of Class A and silicone motor insulation systems. (Class A data: References 7, 8, and 9)

and placed on the line without a dry-out period. The test cycle is repeated until the motor fails.

Part II of the proposed revision of AIEE Standard *1C* describes a similar motor test procedure.

The proposed test code specifies a two-day humidification period. However, because the major change in insulation resistance takes place during the first 24 hours, it follows that a one-day conditioning period is sufficient. This is demonstrated by the changes in insulation resistance shown in Fig. 3. These measurements were made at 500 volts direct current without removing the motors from the tank. Insulation resistance of an unaged motor and a similar motor aged 6,596 hours at 200 C are compared. In each case, insulation resistance decreases rapidly during the first 24 hours and then levels out to a stable low value.

TEST RESULTS

Twist Tests. In Table I, the results of 15 sets of twist tests are given. These were run in accordance with the AIEE Test Procedure. Five of the sets were analyzed statistically by the linear regression procedure.[4] This procedure is a method of fitting a straight line to data having a high correlation. The regression line is an average calculated from the data as a whole, instead of the usual procedure of averaging the failure hours at each temperature. The regression line is based on the assumption that the best straight line for a set of data must be drawn so that the sum of squares of the deviations from a straight line is a minimum.

The 95-per-cent confidence limits for each of the five sets of data were also calculated. These are given in Table I after each regression average. The 95-per-cent confidence limits indicate there is 95 per cent surety that the mean value falls within these limits. The narrow confidence limits indicate that the twist test is reliable. In the development of the Test Code by the AIEE Task Force, this same insulating system was also tested by six laboratories. Essentially, the same results were obtained by each of the cooperating laboratories showing that the test method gives reproducible thermal life values.

A regression line and the average life values calculated from the thermal life values of 15 test sets are also given in Table I. This regression line allows for variations that may be expected when different lots of materials are tested by different personnel at different times. Factors causing variations include different lots of wire enamel and varnish, different curing conditions in the wire tower, operator skill in preparing samples and in applying test voltages, plus fluctuations in oven temperatures that occurred in the three-year period during which these data were collected.

The thermal life data from Table I are shown graphically in Fig. 4. This curve establishes the life–temperature characteristic of the silicone insulation system as determined by the dielectric twist method;[5] the regression line is shown.

Some investigators in this field use a failure voltage criterion higher than the 1,000 volts.[6] To provide data for comparison, the life values of the silicone system were obtained at higher test voltages. These data shown in Table II indicate that higher test voltages do not have an appreciable effect on the life values.

Table III provides thermal life values of the modified silicone enamel when coated on aluminum and on nickel-plated copper wire. It is interesting to observe that the thermal life of the enamel on aluminum wire is almost five times the life on copper wire. The oxidation of the copper at high temperatures probably accounts for this difference. The thermal life obtained on the aluminum wire may be considered as a more accurate representation of the true thermal stability of the insulating system. Since stability of the conductor is obviously on important factor, it also becomes a significant part of the over-all system under test.

The thermal life of enameled magnet wire is also affected by the impregnating varnish. The thermal life of the modified silicone enameled wire dipped in several different varnishes is supplied in Table IV. It readily can be seen that the life is affected appreciably by the varnish.

In the development of the test code for evaluating enameled wires, it was suggested that a water immersion test be included in lieu of the complicated humidity test. The purpose of humidity conditioning is to facilitate finding any flaws or discontinuities in the insulating structure that may result from aging. It follows, however, that increasing the test voltage serves the same purpose. To substantiate this opinion, two series of twist specimens were aged at various temperatures. One set was tested without conditioning; the other set was immersed in tap water for 24 hours at the end of each aging period. The samples immersed in water were subjected to a test voltage of 100 volts alternating current immediately after removal from the water. The thermal life values of the two sets of twists are compared in Table V. Approximately the same thermal life values were obtained with both sets. This indicates that the 1,000-volt test will seek out any flaws caused by thermal deterioration. While this fact is true for the silicone system, it may not be true for organic materials.

Motorette Tests. Ten motorettes were aged at 200, 225, 250, and 275 C. As of November 1, 1955, only the motorettes aged at 275 and 250 C have failed. The thermal

Table I. Thermal Life of Dielectric Twists (AIEE Test Procedure)

Set Number	Thermal Life, Hours				
	300 C	275 C	250 C	225 C	200 C
1		46.8	228.4	1,313	11,773 (0)**
		+1.4, −1.8*	+ 8.7, − 8.1	+ 74, − 80	
2	13.1	50.9	222.8	1,138	>9,495 (1)
	+1.1, −1	+2.5, −2.6	+17.1, −15.8	+101, − 93	
3		80.2	331.3	1,595	8,202 (0)
		+7.9, −7.3	+22.7, −21	+151, −140	
4		74.7	376.8	2,248	8,390 (0)
		+7.9, −7.2	+27.8, −26.0	+252, −225	
5		62.1	258.9	1,242	8,390 (0)
		+6.1, −5.5	+14.0, −13.4	+126, −112	
6		82.2	333.4	1,709	8,202 (0)
7		85.9	234.8	1,556	
8	13.4	68.2	243.2	1,694	
9		87.7	318.4	1,607	6,520 (0)
10		39.4	216.3	1,135	11,773 (0)
11		45.3	251.1	1,259	11,773 (0)
12	15.0	44.2	199.2	1,293	12,845 (0)
13	18.0	76.5	228.6	1,977	14,425 (0)
14	11.0	57.4	189.1		12,574 (10)
15	15.2	46.8	208.7	1,130	
Average of 15 sets, hours		61.0	279.3	1,452	
Calculated regression line, hours		63.8	284.8	1,483	
95-per-cent confidence limits, hours		−7.9, +9.0	−26.6, +24.2	−180, +208	

* Numerals following life values are the 95-per-cent confidence limits.

** Numerals in parentheses indicate twist samples that have failed.

Table II. Thermal Life of Dielectric Twists at Test Voltages Higher than 1 Kv

Set Number	Test Volts, Kv	Thermal Life, Hours				
		300 C	275 C	250 C	225 C	200 C
1	2.0	11.5	66.5	244.9	1,358	
2	2.3	12.8	64.9	243.8	1,439	
3	2.0	10.6	58.8	186.6		12,574
4	3.8	7.4	39.8	191.0		

Table III. Thermal Life of Dielectric Twists on Wire other than Copper

Set Number	Wire Material	Test Volts, Kv	Thermal Life, Hours				
			300 C	275 C	250 C	225 C	200 C
1	No. 18 Ni	2.9	20.9	106.2	463.4		
2	No. 18 Al	1.0	47.3	198.2	995.4	5,331	9,805 (0)
3	No. 18 Al	2.9	25.4	147.6	623.7		
4	No. 18 Al	2.9	30.6	169.4			

Table IV. Effects of Varnish on Thermal Life (No. 18 Enameled Wire, 1 Kv, 10 Types)

Varnish Number	Varnish Type	Thermal Life, Hours		
		250 C	225 C	200 C
A	Organic	341	1,251	2,805
B	Alkyd, fatty acid	179	765	6,041 (3)*
C	Oil modified phenolic	211	1,010	6,041 (9)
D	Oil modified phenolic	164		6,041 (9)
E	Oil modified phenolic	254	899	1,612
F	Oil modified phenolic	69	189	1,021
G	Oil modified phenolic	274	1,083.8	
H	Alkyd, melamine	175	634	6,041 (9)
I	Oil modified alkyd	57	193	1,098
J	Oil modified phenolic	243	973	2,737
K	Phenol-formaldehyde	239	1,058	5,577 (7)
L	Organic	165	456	2,025
M	Organic	192	464	874
N	Epoxy, urea-formaldehyde	119	754.4	
O	Modified silicone	498	1,462	6,960
P	Silicone	86	221	1,552

* Numerals in parentheses are number of twist specimens that have failed.

Table V. Effect of Moisture on Thermal Life

Test Condition	Average Thermal Life, Hours 275 C	250 C	225 C
Dry, 1 kv	85.5	221	1,552
D-24/25, 100 volts a-c	82.0	276	1,721

Table VI. Motorette Life Data

Motorette Number	Life in Hours 275 C	250 C	225 C	200 C
1	30*	30*	835	2,500
2	36	150	1,333	4,227
3	36*	180	1,333	>4,227
4	42	180*	1,621	>4,227
5	42	210*	1,621*	>4,227
6	48	240*	1,621*	>4,227
7	48	240*	1,621	>4,227
8	48	270*	1,621*	>4,227
9	48	300	1,621*	>4,227
10	48	300*	1,621*	>4,227
Average life, hours	42.1	226.5	1,452	
95-per-cent confidence limit, hours	+5.3, −4.9	+31.1, −27.4	+192, −170	

* Motorettes failed voltage test following humidification; all others failed voltage test applied after the heat aging period.

Note: The turn-to-turn test voltage used in these tests was 120 volts alternating current; all failures were turn-to-turn.

Table VII. Motor Life Data

275 C	Life in Hours 250 C	225 C	200 C
58	234	619	3,217
60	411	841	4,334
68		1,008	4,738
		1,828	4,788
		1,967	7,396
			8,723
			12,549
			12,549
			13,200
			>9,274*
			>9,635*
Average life	62	322	1,255

* Motors still running as of November 1, 1955.

Note: All failures were turn-to-turn as far as can be determined; all motors failed during the running period at high temperature.

life data obtained from all motorettes are given in Table VI. The average life and 95-per-cent confidence limits are given for the two temperatures at which all the motorettes have failed. Although the data are not complete, the confidence limit indicates the consistency of the results. The data in Table VI are shown graphically in Fig. 5. A line has been drawn through the three failure points to provide an estimate of the life–temperature characteristic for the insulation system.

Motor Tests. The thermal life values obtained on the motors are given in Table VII.

Fig. 6 illustrates the thermal life–temperature characteristic of the complete silicone insulating system. Each motor failure is shown in this graph. Also indicated is an area which includes all of the motor life values. It may be assumed that the average motor life value falls within this area.

DISCUSSION

THE RESULTS obtained by these three test methods are compared in Fig. 7. The life–temperature line determined by each method on the same basic insulation system falls within a narrow range. Under these test conditions, then, the silicone system degrades according to a linear law in terms of the graph co-ordinates. This relationship will hold true at any temperature, if no new variable is introduced affecting the test results. Considering the many variables already present in the evaluation at higher temperatures, it is reasonable to assume that the data may be extrapolated to 180 C. Because of the excellent correlation among the life values, these test methods will be of valuable assistance in evaluating insulation systems. As other test codes are developed for different materials and apparatus, it is hoped the results will correlate as consistently as these three methods discussed.

As mentioned, the primary purpose of the program was the evaluation of a particular insulation system. It is felt that sufficient data have been collected to provide a basis for estimating the thermal stability of the silicone system. In Fig. 8, the thermal life of the silicone system is compared with the thermal life of Class *A* systems taken from published data.[8,9] These Class *A* data were obtained by methods similar to those used in this study.

Fig. 8 shows that the thermal life of Class *A* insulation systems is in the range of 10,000 to 30,000 hours at 105 C. However, Class *A* motors last much longer than these tests would indicate. Field experience has proved that the Class *A* systems will give long and satisfactory life in the order of 10 to 20 years under normal operating conditions. Obviously, these accelerated tests are more severe than normal operating conditions. Therefore, the life determined by test must be multiplied by a factor of approximately 8 to obtain the normal life expectancy. This is because most motors are not operated continuously nor are they always at full load when running. Furthermore, the temperature rise of most Class *A* motor designs is based on a 40 C ambient temperature. Most motors do not operate continuously at full load in a 40 C ambient. On the other hand, the test equipment operates continuously at the high temperatures. Therefore, a factor of this magnitude is reasonable when the life of the test equipment is compared with that of motors in "normal" service.

The logical conclusion is that a life value in the range of 10,000 to 30,000 hours for Class *A* systems at 105 C establishes a bench mark against which the life of other insulating systems may be compared. A bench mark such as this must be recognized if the test procedures under development by the AIEE are to be of value as methods for evaluating the thermal life of materials. This assumes, of course, that the life–temperature characteristic for the system in question has been established from enough reliable data to make bona fide extrapolation to the hottest spot temperature.

Therefore, comparing the thermal life of the silicone system with that obtained on Class *A* systems, it is concluded that the silicone system consisting of Sykyd enameled wire and silicone varnish *997*, together with suitable Class *H* components in random-wound electric machinery will

have a life expectancy at a hottest spot temperature of 180 C comparable to that of Class *A* systems at 105 C. Since the AIEE Standard Number 1 definition of Class *H* does not exclude the use of enameled magnet wire, the silicone system qualifies as Class *H* as defined in this standard.

CONCLUSION

The thermal life values obtained on the insulation system by three test methods show excellent correlation. Data have been presented to show that the modified-silicone enameled wire together with silicone components provide an insulation system in random-wound electric machines qualifying for operation at Class *H* temperatures.

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Pump-Turbine Addition at TVA Hiwassee Hydro Plant

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Studies in preparation for the installation of a second unit at Hiwassee Dam showed that the 26-per-cent additional installed cost of a pump-turbine-type unit was justified by economic and operating advantages. Design and operation characteristics of this 80,000-hp unit, as well as the field test to be given after initial operation, are discussed.

HIWASSEE DAM, built by the Tennessee Valley Authority (TVA), is located in the southwest corner of North Carolina on the Hiwassee River, a tributary of the Tennessee River. The total storage volume provided by this dam is 438,000 acre-feet, of which 304,700 is useful controlled storage. Construction was started in July 1936, and power generation began in May 1940.

Operation of the project, which is conducted on a multipurpose basis, is integrated with two upstream reservoirs, Chatuge and Nottely, both completed in 1942, and also with Apalachia Dam, located 9.8 miles downstream. The latter project, completed in 1943, creates a reservoir extending to Hiwassee Dam.

The original installation at Hiwassee consists of one 120-rpm Francis-type turbine rated 80,000 hp at 190-foot head and a generator rated 64,000 kva, 60 cps, 0.9 power factor. Design provisions were made for the installation of a duplicate unit at a later date.

Fig. 1 shows a general view of the powerhouse and dam. A 275-ton gantry crane of the outdoor type is provided to handle the turbine and generator parts through roof hatches. The hatch cover for Unit *1* can be seen below the crane. Unit *2* is now being installed on the river side of Unit *1*.

PUMP TURBINE RECOMMENDED

STUDIES WERE BEGUN, in 1951, in preparation for the installation of the second unit at Hiwassee. At that time the development of the pump turbine had reached such a stage that a unit of this type could be considered for this project. The Hiwassee plant is well suited for a pumped storage development, because the lake formed by Apalachia Dam backs up to the Hiwassee powerhouse and provides approximately 8,700 acre-feet of water for pumping. This is equivalent to about 27 hours of pumping at rated pump capacity.

A thorough study of the benefits to be derived from the installation of a pump-turbine unit as compared with the addition of a conventional turbine was made by the planning branch of TVA, with the result that installation of a pump-turbine unit was recommended. This study indi-

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cated that a satisfactory return on the 26-per-cent additional installed cost of a pump turbine would be realized because of the increased on-peak energy and generating capacity available. In addition, important but intangible benefits may be realized, such as increased flexibility of system operation and the maintenance of higher heads at other plants. The upward trend in capacity charges and possible greater differential between peak and off-peak energy costs would also enhance the advantage of a pump-turbine-type installation.

Fig. 2*A* shows the expected additional available capacity for the period of high system load. The additional capacity is a result of the higher head mantained on both units by off-peak pumping. Typical weekly operation during this period is shown by Fig. 2*B*. Additional information in regard to expected operation is available.[1,3]

After considerable consultation with the pump-turbine manufacturer, the Allis-Chalmers Company, Milwaukee, Wis., it was decided that the unit should be rated 80,000 hp at a 190-foot net head and should operate at a speed of 105.9 rpm. It would rotate clockwise as a turbine. It was also decided that for pump operation the unit should be rated 3,900 cubic feet per second (cfs) at 205-foot net head and operate at a speed of 105.9 rpm. Operation as a pump would be counterclockwise.

During the early stages of planning, several alternate pump-turbine units were considered. It was first thought that the limiting factor would be the largest size runner that could be shipped in one piece. Such a unit would have been rated approximately 48,000 hp at 190-foot net head as a turbine and 2,500 cfs at 205-foot net head as a pump. This size would have been inadequate for TVA's requirements as a turbine; therefore, it was decided to build the runner in sections and assemble it in the field. The runner being installed is made in three sections and is bolted together.

A 2-speed unit, that is, one which would operate at one speed when generating and a different speed when pumping, was also considered. The 2-speed type has the advantage of better efficiency, inasmuch as maximum efficiency of the unit for turbine operation occurs at a lower speed than for pumping. However, the generator manufacturers consulted did not consider it advisable to design a pole-changing 2-speed synchronous-type unit of this size. Cost, crane lift, and space requirements also would have been prohibitive for this installation.

The unit finally selected was the largest, physically, that could be installed in the space available, and the speed selected was a compromise between best speed for pumping and best speed for generating.

Table I lists ratings and other pertinent data for Unit *1* turbine and generator and, also, for the Unit *2* pump turbine and generator motor.

Fig. 1. Hiwassee project, 1940, Unit 1 installed

DESCRIPTION OF PUMP TURBINE

The Hiwassee pump-turbine unit is similar in appearance to a conventional Francis-type turbine. The embedded parts consist of plate-steel draft-tube liner, plate-steel discharge ring, cast-steel stay ring, plate-steel spiral case, and plate-steel pit liner, as shown in Fig. 3. The spiral case is of welded construction and is welded to the stay ring, as shown in Fig. 4. The shop welds were furnace annealed. To minimize the amount of field welding required, the stay ring and spiral case sections were made as large as consistent with ease of handling and shipping. The field welds were stress-relieved by the low-temperature flame stress-relieving process, and the completed stay ring and spiral case were hydrostatically tested at a pressure of 1.5 times the design pressure.

Flow of water to the impeller runner is controlled by 20 cast-steel wicket gates. The wicket gates are connected by suitable levers and links to the shifting ring which is, in turn, connected to the 2-gate servomotors. The servomotors, acting under oil pressure from the governor, control the wicket-gate opening.

The impeller runner is the part that most distinguishes the pump turbine from the conventional Francis type. Fig. 5 shows the runner in the erection area after the three sections were bolted together. The runner for the Hiwassee unit has six vanes compared with 19 in the conventional unit, and its diameter at the center line of the distributor is considerably larger. It is set 6 feet lower with respect to tailwater than the conventional runner. The larger diameter and lower setting are dictated by the pumping requirements of the unit.

A number of accessories, ordinarily not provided for a conventional turbine required for the pump turbine are:

1. Draft-tube trashracks are provided to prevent trash from entering the impeller runner during pumping operation. It is important that these trashracks do not become clogged and lower the effective tailwater level sufficient to cause cavitation in the impeller runner. To prevent operation of the unit as a pump under these conditions, an additional tailwater level indicator has been provided inside the trashracks. This gauge is equipped with electric contacts for alarm and shutdown in case the effective tailwater level becomes too low.
2. Equalizing pipes are connected between the head cover and the draft tube to decrease the pressure under the head cover. This reduction in pressure has the effect of reducing the hydraulic thrust and reducing the disk friction.
3. Two indicating flowmeters are provided for Unit 2—one for turbine operation and one for pump operation.

These are connected to the station flowmeter which records and totalizes the net plant discharge. The net discharge is the total drawn by both units from the Hiwassee Reservoir, minus the amount returned to the reservoir by pumping operation on Unit 2.

4. Wicket-gate brakes are provided to prevent chattering or vibration of the wicket gates, since model tests and operating experience on similar units have indicated that chattering might occur at certain gate openings. The brakes are air-operated and act directly on the gate stems. They are automatically controlled so that the braking pressure is reduced when the gates are moving in either direction and applied at full pressure when they are stationary. The brakes are not used when the unit is operating as a turbine.

5. The usual facilities are provided for blowing the water down below the runner to reduce the power required for operation of the unit as a synchronous condenser. Another use for the blowdown facilities will be to reduce the torque required when starting as a pump. Blowdown may also be useful for gradually reducing the power input to below the input required at closed gate, when shutting the unit down from pumping operation.

Model Tests. During the design of the pump turbine, the manufacturer made a number of tests on an 18-inch homologous model to supplement other design work and to demonstrate that the pump turbine will have the desired characteristics. Tests of the final model impeller runner were witnessed by TVA personnel.

From these tests its was determined, using a conservative efficiency "step-up" factor, that the unit will meet the manufacturer's efficiency guarantees for both pump and turbine operation. The tests also indicated that the pump capacity guarantees will be met at all heads and that the turbine capacity guarantees will be exceeded below 200-foot net head, but will not meet the guarantee at 220-foot net head by about 2,000 hp. However, since the generator capacity limits the power output at heads above 200 feet, it is obvious that increased turbine output at the higher heads would be of little value; therefore, no attempt was made to effect such an increase.

Tests were also made to determine the cavitation characteristics of the unit, both as a turbine and as a pump. These tests indicated that for turbine operation, cavitation would not occur under any normal condition. For pumping operation, the tests indicated that the limits imposed by the manufacturer, in the contract, were satisfactory. It was also determined that the pump could be operated at a somewhat lower head than dictated by the cavitation limit by throttling the pump discharge with the wicket gates. However, because of decreased efficiency, this low-head operation would not ordinarily be worthwhile.

In designing the impeller runner, it was necessary to give consideration to the power requirements for pump operation, since the first model tested indicated that the power required by the pump would exceed the maximum rating of the motor by about 4 per cent. To lower the power input to the motor, the manufacturer reduced the vane diameter of the model's impeller by an amount equal to about 1 inch on the prototype. This had the effect of

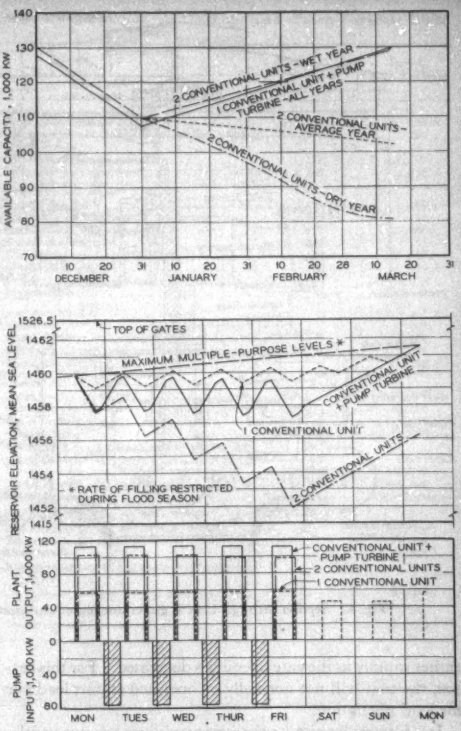

Fig. 2. (top) Available plant capacity during period of high system load. (bottom) Typical weekly operation during period of high system load

reducing the pump horsepower to an acceptable value and of reducing the pump capacity to approximately 3,800 cfs at a 205-foot net head. The pump efficiency and turbine characteristics were substantially unchanged. Because of the inability to exactly predict prototype performance from a model test, it was decided to build the impeller runner with a diameter of 266 inches and do any necessary trimming of the vanes in the field after capacity tests are made.

To summarize, the model tests showed that a pump turbine could be built to meet TVA's requirements for a pumped storage unit for the Hiwassee project. The exact operating characteristics of the unit will be determined by field tests.

Operating Characteristics. Figs. 6 and 7 show the expected performance of the unit, operating as a turbine and as a pump, respectively. These curves are based on model test data, guaranteed generator efficiencies, and calculated penstock losses. It will be noted from Fig. 6 that the maximum efficiency of the unit when generating occurs at maximum or nearly maximum gate opening and drops off

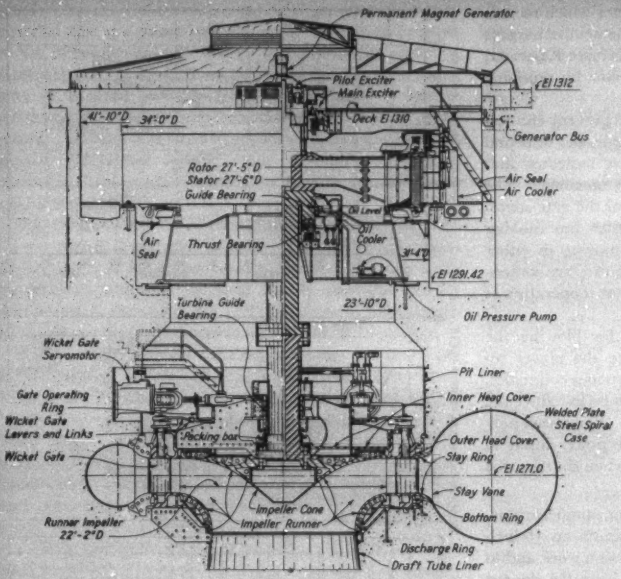

Fig. 3. Section through Unit 2, generator motor and pump turbine

efficiency plotted against pump discharge. This curve was computed from model test data.

GENERATOR-MOTOR DESIGN

Co-ordination of the generator-motor design with the pump turbine, main transformer, and transmission-line characteristics involved a series of interesting investigations before the final design was selected. The required motor output of 102,000 hp, or 76,092 kw, established a frame size larger than the generator, required to match the turbine rated output of 80,000 hp. This led to the decision to rate the motor at 80 C rise. A unity power-factor motor, although least expensive, was found unsuitable because of its lack of reactive capacity to control transmission-line and main-transformer regulation. Although a lower power factor was desirable, a compromise figure of 0.95 was selected in order to limit the rotor weight to that established by the capability of the existing powerhouse crane. The motor rating was thus established at 102,000 hp, 0.95 power factor, 80 C rise, 13,500 volts, and 105.9 rpm. The corresponding generator rating was specified as 59,500/68,425 kw, 70,000/80,500 kva, 60/80 C rise, 0.85 power factor, and 105.9 rpm.

Higher than normal flywheel effect was not required. The relatively high inertia constant of 3.71 shown in Table I for generator plus turbine was inherent in the design.

The generator motor was furnished by the Allis-Chalmers Manufacturing Company. As shown in Fig. 3, it is enclosed in a concrete barrel constructed integrally with the powerhouse structure, the same as Unit *1*. A removable fabricated steel cover placed just above the powerhouse deck level provides crane access for assembling and dismantling the generator motor and pump turbine.

The directly connected main and pilot exciters are telescoped to reduce headroom requirements. An 84-inch-

rather rapidly as the gate opening is decreased. For this reason, the unit will not normally be operated at part load nor for load regulation.

It is interesting to note that the maximum runaway of the pump turbine is only about 42 per cent above rated speed, while maximum runaway speed of the conventional unit is almost 100 per cent greater than rated speed.

As shown on Fig. 7, the over-all efficiency of the unit when pumping is quite high over the entire operating range. The exceptionally flat curve is partially because of the movable wicket gates. For instance, if the unit were operated against a 240-foot head (2,900 cfs) at the gate opening recommended for a 190-foot head (4,200 cfs), the efficiency at the 240-foot head would be about 7 per cent poorer than that shown on the performance curve. The lower curve of Fig. 7 shows the gate opening for best

Photo courtesy Allis-Chalmers Manufacturing Company

Fig. 4. Pump turbine, shop-assembled stay ring and spiral case

Fig. 5. Unit 2, pump-turbine runner as assembled at site

diameter Kingsbury thrust bearing is located below the rotor, and each of the 8 thrust shoes are provided with a high-pressure oil connection for reducing the starting friction. A motor-driven pump mounted externally on the lower bearing bracket furnishes the high-pressure oil supply.

Six air coolers for the stator are mounted tangentially to the stator wrapper plate. A shop view which illustrates partially stacked rotor is shown in Fig. 8. The normal practice of TVA is to install discontinuous-type damper windings; however, the continuous type, as shown in Fig. 8, were required by the pump start duty. Note the straight-type fan blades mounted above the rotor. This type blade is required for reversible rotation operation.

Ventilating air supply for the exciters is obtained from the generator room and discharged through vents in the generator hatch cover above the exciters. Provision is made to discharge this air back into the generator room when required to reduce station heating requirements.

Motor Start Methods. Various methods considered for starting as a motor included: (1) full voltage, normal frequency; (2) partial winding at normal voltage and frequency; (3) synchronous start from standstill by means of 13.8-kv connection to Unit *1;* (4) induction start at reduced voltage and frequency by means of 13.8-kv connection to Unit *1;* and (5) reduced voltage, normal frequency, by connecting the motor to a 6,600-volt tap on the main transformer 13,200-volt winding.

Method *1* could not be used because full voltage start would impose a 158,000-kva demand on the 161-kv system. The generator designers did not recommend the use of partial winding start, method *2,* for this type machine. Methods *3* and *4* were practicable but required the use of Unit *1* for each daily start during the pumping season. Method *5* was adopted since it was calculated that the motor could be accelerated to normal speed in less than 2 minutes with a start kilovolt-amperes of about 35,000 with water depressed below the pump runner. This method, in addition to being entirely independent of Unit *1,* had a favorable cost factor and was particularly adaptable to a relatively simple control of all pump-turbine and generator-motor operations from the main control room. The TVA system now has 42 hydro units operating with this type of remote control, and has 6 supervisory-controlled units in unattended plants.[3]

Table I. Comparison of Turbine and Pump-Turbine Units

	Unit 1, Turbine		Unit 2, Pump Turbine
Normal speed, rpm	120		105.9
Runner diameter at distributor center line, inches	161		266
Elevation			
Distributor center line, feet	1,277		1,271
Bottom of draft tube, feet	1,240		1,238.5
Turbine characteristics			
Rated head, feet	190		190
Best efficiency head, feet	200		240
Rated output, hp	80,000		80,000
Runaway speed, rpm	235		161
Efficiency at rated head and hp	84.7		87.3
Maximum efficiency	90.0		89.4
Flywheel effect, pounds/square foot	2,600,000		18,000,000
Manufacturer	Newport News		Allis-Chalmers
Pump characteristics			
Rated head, feet	...		205
Rated discharge, cubic feet/second	...		3,900
Efficiency at rated head and discharge, per cent	...		.90
Maximum efficiency	...		90
Generator characteristics			
Rated output (60 C), kva	64,000		70,000
Capability (80 C), kva	73,600		80,500
Power factor, per cent	90		85
Voltage	13,800		13,800
Efficiency at rated output and power factor, per cent	97.4		97.1
Flywheel effect, pounds/square foot	60,300,000		82,818,700
Thrust bearing total load, pounds	1,104,000		1,365,000
Manufacturer	Westinghouse		Allis-Chalmers
Motor characteristics			
Rated output (80 C), hp	...		102,000
Power factor, per cent	...		95
Voltage	...		13,500
Efficiency at rated output and power factor, per cent	...		97.4
Input kva at rated output and power factor	...		82,250
Generator plus turbine			
Inertia constant, kw second/kva	3.25		3.71

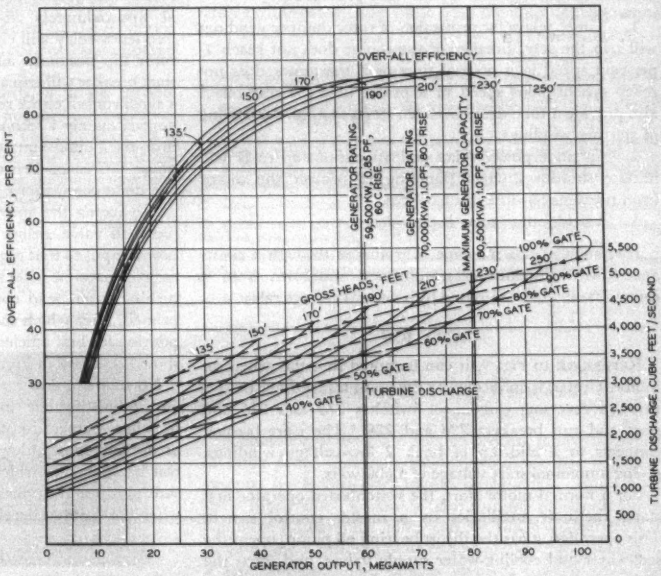

Fig. 6. Unit 2 characteristics when generating

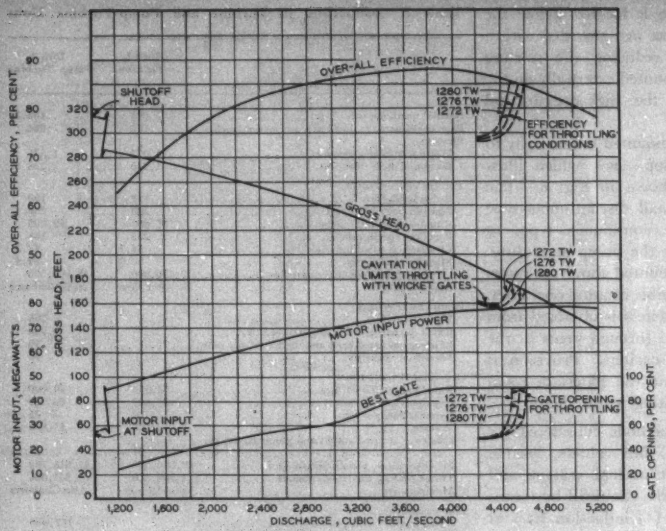

Fig. 7. Unit 2 characteristics when pumping

Generator-Motor Protection. In addition to the split-phase differential, overcurrent backup, and ground-fault relays normally installed for the TVA hydro generators, the following protective devices were provided:

1. Timer relays for protection of rotor damper windings will trip the start breaker, if the motor does not reach 1-per-cent speed in a normal time or if the motor does not reach synchronous speed in a preset time. These relays also provide a time delay between starts to allow for cooling of starting windings.
2. An underpower relay and an out-of-step relay will initiate shutdown when pumping to protect the motor from transmission-line disturbances.
3. A field-failure relay is provided.

Inasmuch as this machine is grounded through a resistance-loaded distribution transformer, shutdown from a ground fault will be initiated by a neutral voltage relay.

OPERATION

Referring to Fig. 9, it can be noted that the generator motor, Unit *2*, is connected to the main transformer bank *2* through reversing disconnect switches *213* and *215* and start and run breakers *226* and *228*. The start breaker connects to a mid-tap of bank *2* low-voltage windings, giving a nominal start voltage of 6,600 volts.

For a normal motor start, the switchboard operator first starts the unit auxiliaries by a master control switch. This operation starts the thrust bearing oil pump, opens the seal-water and cooling-water supply valves, and starts the turbine-bearing oil pump. By placing the operation selection switch in the pump position, disconnect switch *213* is closed and the motor-operated rheostat for the main exciter field is run to a preselected position.

Before the start breaker can be closed, the following interlocks must indicate that conditions are normal: (1) head gate open; (2) pump switch (*213*) closed; (3) governor oil pressure normal; (4) air brakes released; (5) thrust-bearing cooling-water flow normal; (6) turbine-seal water flow normal; (7) turbine-bearing oil level normal; (8) thrust-bearing starting oil pressure normal; (9) exciter field rheostat in the preselected "start" position; (10) tailwater level inside draft tube above the limiting minimum elevation; (11) water depressed below the pump impeller; (12) field breaker open; and (13) pilot exciter field-reversing switch must be in pump position.

When all interlocks are in the position required for starting, as indicated by a lamp on the benchboard, the operator will close the start breaker, which initiates the following sequence: (1) motor will start at reduced voltage; at approximately 95-per-cent speed, a polarized field frequency relay will close the field breaker at the optimum rotor slip position; and (2) after a short time delay, the start breaker will trip and the run breaker will close through a synchronism check relay; the open transition time will be approximately 1 second, as required for the motor rotor to drop back approximately 60 electrical degrees, which is the phase difference between the main transformer start and run delta connections.

Advancing the gate limit setting will then open the air bleed-off valve, prime the pump, and build up the motor power input to that required by the pump at shutoff head, or approximately 27,000 kw. A float switch connected to the turbine outer head cover will indicate when the pump is primed, after which the wicket gates can be opened to the position for best efficiency at the existing operating head, as shown on curve in Fig. 6.

Normal shutdown will involve closing the wicket gates and admitting air to depress the tailwater below the impeller. Operation can then be continued as a condenser; or if complete shutdown is required, the operator will trip run breaker *228*, which starts the thrust-bearing oil pressure pump and applies the brakes of the generator motor when the unit has decelerated to 50-per-cent speed.

FIELD TESTS

Pump-Turbine Tests. The TVA plans to make complete efficiency and capacity tests of the pump turbine for both

pump and turbine operation as soon as practical after initial operation. The Allen salt-velocity method was chosen for determining the flow through the unit because it is readily adaptable to either pump or turbine operation. The principle of this method is to inject a quantity of salt solution into the penstock and measure electrically the time required for the solution to travel a known distance between two points in the penstock. This travel time is used for computing the average water velocity.

It is tentatively planned to make pump tests at both high- and low-tailwater elevations and at sufficient different gate positions to determine the gate opening that gives best efficiency for the conditions existing at the time of each test. Turbine tests will cover the entire range of gate openings, so that a complete characteristic curve for the head existing at the time of the test will be obtained.

Data obtained from these tests will be used to revise the operating characteristic curves, to calibrate the pump and turbine flowmeters, and to check the manufacturer's efficiency and capacity guarantees.

Generator-Motor Tests. A complete set of segregated loss tests by the deceleration method will be made after completion of the initial operation tests. Supplemental tests with oscillographs will also be made to determine starting and pull-in characteristics for motor operation.

CONCLUSIONS

THE FOLLOWING CONCLUSIONS necessarily apply only for the hydraulic and operating conditions at the Hiwassee hydro plant:

1. The 26-per-cent additional installed cost of a pump-turbine-type unit at Hiwassee was justified by the economic and operating advantages that will be obtained as compared to a conventional-type unit.

2. As demonstrated by model tests, a pump turbine with good efficiency for both pump and turbine operation at a common speed can be built. The efficiency as a turbine drops off rather rapidly as the gate opening is decreased; however, the unit will not be normally operated at part load.

3. Generator-motor frame size and cost were established by the motor requirements.

4. Of the several motor starting methods investigated, a reduced voltage start utilizing a main transformer mid-tap was found advantageous from the operation, control, and cost viewpoints.

5. Water should be depressed below the runner during the start cycle since 36 per cent of full-load torque is required at the pump shutoff head.

6. Semiautomatic control of the pump turbine and generator motor starting and operation was found practicable with remote supervision from the main control room.

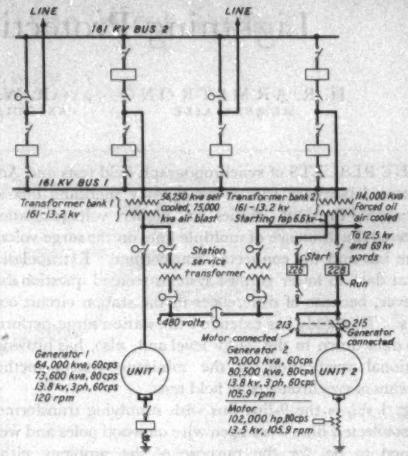

Fig. 9. Connection diagram, Units 1 and 2

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Fig. 8. Unit 2, 70,000-kva/102,000-hp generator-motor shop view of partially stacked rotor with poles fitted

Photoengraving Process

A photoengraving plate-making process, many thousands of times faster than conventional methods, has been developed by Radio Corporation of America. Employing the "Electrofax" system of electrostatic photography, a complete lithographic plate can be made in less than a minute, and a printing plate can be prepared for etching in a few minutes. The process involves coating metal or other surfaces with inexpensive pigment for direct exposure. This process may be applied to printed circuits.

Lightning Protection in a 24-Kv Station

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THE RESULTS of synchronograph field tests and Anacom laboratory studies on a 24-kv multiline bus are presented. Previous studies on higher voltage stations indicated the influence of multiple lines on the surge voltage at the bus and the connected transformer. Extrapolation of that data to lower voltage systems seemed questionable, however, because of differences in the station circuit constants. This study has extended the station surge-performance data down to the 24-kv level and, also, has provided additional verification of the miniature-system method by means of synchronograph field tests.

Fig. 1 shows the 9-line bus with supplying transformer. The connected lines were open wire on wood poles and were assumed to be, for the purpose of the problem, either shielded or unshielded. For the case of shielded lines, the basic impulse insulation level (BIL) of the line insulation was 750 kv. Both the 25-kv class transformer and the 23-kv class circuit breakers had 150-kv BILS. Arresters were 20 kv line-type. For stations having shielded overhead lines, lightning protection was based on the case of a backflash occurring 1 mile from the station, which resulted in a 700-kv 1.5 × 8 microsecond surge arriving at the station entrance. To evaluate the required degree of lightning protection for stations with unshielded overhead lines, a 10,000-ampere stroke having a 4,000-ampere-per-microsecond rate of rise was assumed to terminate at the station entrance.

One phase of the 24-kv station, shown in Fig. 1, was set up on the Anacom. The distributed constants of the bus structure were represented by pi-sections.

Each circuit breaker was represented by its bushing capacitance of 300 micromicrofarads per bushing and the transformer was represented by a 2,000 micromicrofarad capacitor. A low-voltage surge was applied repetitively to the computer circuit and resultant voltages at the terminals were measured by an oscillograph.

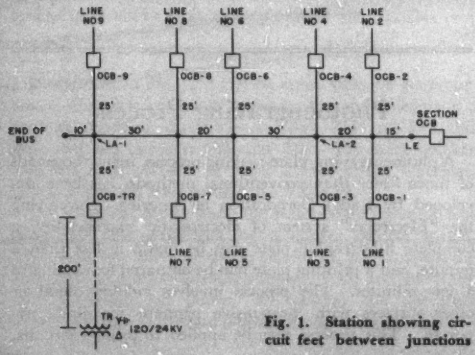

Fig. 1. Station showing circuit feet between junctions

To verify the assumptions made in setting up an electric system on the Anacom, synchronograph field tests were made on the 24-kv station (Fig. 1). Surges were applied at the section breaker through a resistance equal in value to the surge impedance of the transmission line; voltages were measured at the line entrance *LE*, at the transformer *TR*, and at the end of the bus. Tests were made both with and without an arrester at the line-entrance position, and the circuit breakers were closed in sequence to show the reduction in surge voltage because of the multiple circuits. Duplicate circuit conditions were set up on the Anacom to obtain comparative data. The miniature system used in the Anacom gave results that agree closely with the synchronograph field tests.

CONCLUSIONS

1. Although low-voltage stations are compact and have high values of capacitance-to-ground, the high BIL of modern wood-pole lines permits high surge voltages to enter the station.

2. The ratio of the line BIL to the equipment BIL is much higher in low-voltage systems than in higher voltage systems. Therefore, with no arrester in the station, the resultant surge voltages per unit of the equipment BIL at terminals are much higher in low-voltage stations.

3. Connected lines cannot sufficiently reduce the surge voltages within the station, so that the station is inherently self-protecting without lightning arresters. Even with all nine lines connected, for the case of stations with shielded lines, the surge voltage at the transformer is more severe than the insulation strength of the 150-kv BIL transformer.

4. For stations with shielded overhead lines, and with only one 20-kv line-type lightning arrester at *LA-1* (Fig. 1), two or more connected lines are necessary to afford adequate protection to the station equipment.

5. For stations with unshielded overhead lines and with only one 20-kv arrester at *LA-1*, four or more lines are necessary to provide protection for the station apparatus.

6. With two arresters in the station at *LA-1* and *LA-2*, the station is adequately protected regardless of the number of connected lines.

7. From this and previous comparisons of field and miniature-system studies made on stations covering a range of voltage levels, it is concluded that when the dimensions and circuit constants of the station are accurately known, the results of miniature-system studies of circuit surge performance can be used with confidence in formulating the required lightning protection.

Digest of paper 55-556, "Lightning Protection in a 24-Kv Station—Field and Laboratory Tests," recommended by the AIEE Committee on Protective Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Published in AIEE *Transactions*, vol. 74, pt. III, 1955, pp. 1127–36.

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VHF Radio Link in the West Indies

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THIS SYSTEM has been installed in the West Indies to connect the public telephone and cable services of the island of Puerto Rico with similar services in the nearby Virgin Islands. As shown in Fig. 1, there are two radio links, one of 69 miles from Sabana Llana, Puerto Rico to Crown Mountain on St. Thomas Island, and one of 45 miles from Crown Mountain to Christiansted on St. Croix Island. The three radio stations are connected through cables to their telephone exchanges and telegraph offices.

The Crown Mountain station is located at an altitude of 1,550 feet while the other stations are near sea level. The radio path from Crown Mountain to Christiansted is above the horizon, but that to Sabana Llana is below the geometric horizon and barely above the "effective radio horizon" based on a 4/3 radius earth. Corner reflector antennas with a gain of 8 db are employed, and the radio frequencies are 152.57, 152.75, 157.83 and 158.01 megacycles.

Frequency modulated transmitters with power outputs of 25 and 100 watts, respectively, are used on the Christiansted and Sabana Llana links.

The receivers are crystal-controlled double-conversion superheterodynes with automatic volume control, two limiting stages, and a discriminator. A transmitter and receiver together are capable of a system response-frequency characteristic that is flat to within 1 db from 200 cps to 20 kc with less than 1 per cent amplitude distortion and a 50-db signal-to-noise ratio per 3-kc channel.

Spare radio equipment is installed at each location. Fig. 2 shows the transmitting and receiving apparatus at one of the stations.

In addition to a voice channel, three other channels are obtained through use of telephone-type single side-band carrier equipments. The voice channel is transferred at Crown Mountain from one link to the other by means of low- and high-pass filters to provide a direct circuit between St. Croix and Puerto Rico. The carrier channels are used for intercommunication between adjacent islands.

Standard telegraph carrier equipments with frequency shift keying are installed to subdivide one of the telephone channels into several printer channels.

Digest of paper 55-751, "VHF Radio Link Between Puerto Rico and the Virgin Islands," recommended by the AIEE Committee on Radio Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955. Published in AIEE *Communication and Electronics*, January 1956, pp. 781–5.

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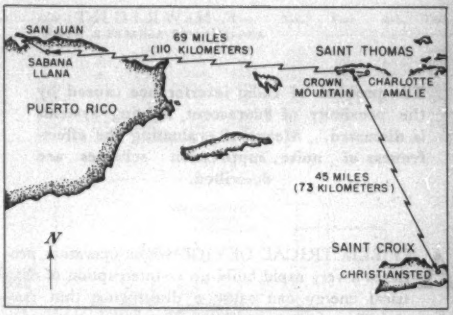

Fig. 1. Map of system

Over-all unweighted signal-to-noise ratio at the telephone switchboards, including noise contributions from lines, carrier equipment, radio apparatus and crosstalk is about 35 db. During the initial period of 18 months' operation that commenced in August 1953, commercial service has been maintained 99 per cent of the time between Puerto Rico and St. Thomas and 97 per cent of the time between Puerto Rico and St. Croix. Since that time, reliability has been further improved by correcting various minor faults in the installations.

This service is much better than that provided by the former radio links between these islands which used sky wave transmission of amplitude-modulated frequencies of the order of 4 to 7 megacycles.

Fig. 2. Transmitters and receivers at Crown Mountain station

Evaluation of Radio Influence Voltages in Fluorescent Lighting Systems

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S. A. ZIMMERMANN
MEMBER AIEE

The problem of radio interference caused by the proximity of fluorescent lighting systems is discussed. Means of evaluating the effectiveness of noise suppression schemes are described.

ANY ELECTRICAL DEVICE whose operation produces a very rapid build-up or interruption of electrical energy can cause a disturbance that may adversely affect radio reception. The commutator of a d-c machine represents a mechanical means of producing r-f power from electrical transients. A fluorescent lamp represents an all electrical voltage breakdown type of transient that produces modulated r-f energy. If no effort is made to confine this energy, nearby radio sets may experience a poor signal-to-noise ratio. This article discusses primarily the radio influence voltages associated with commercial and domestic fluorescent lighting systems. The principle subjects considered are

1. The mechanism of r-f energy coupling between the lighting system and the radio.
2. A test method that makes possible the assignment of an approximate numerical value to the probable radio influence voltage of a fluorescent lighting system.
3. A statistical means of critically evaluating the probable radio influence voltage of a fluorescent lighting system.

COUPLING BETWEEN LAMP SYSTEM AND RADIO

To cope with the unwanted radio frequency energy, it is necessary to consider the energy radiated directly from the lamps and fixture, the energy conducted to the radio directly through the power circuitry, and the energy radiated from the wiring that supplies the power to the lighting system. The latter energy is usually the most important of the three components. Direct radiation from the lamps and fixture can readily be disposed of by stating that the radio antenna should be physically remote[1] (10 feet is a conservative distance) from these objects, and the fixture should be properly grounded. The remainder of this article is concerned primarily with supply line radiation and radio influence voltages conducted directly to the radio. They are so interlinked it is unnecessary to treat them separately. In some cases, it may be necessary to consider the possibility of radiated energy from the lamps coupling with the wiring and then reradiating from the wiring.

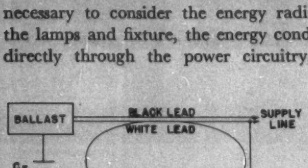

Fig. 1. Radiation loops of power input wiring

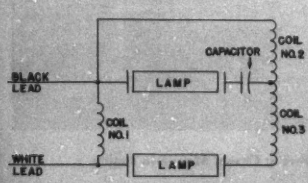

Fig. 2. Schematic diagram of series ballast circuit[2]

MEANS OF EVALUATING SUPPRESSION

IT IS VERY IMPORTANT to realize that the power wiring to the ballast, normally thought of as a two-wire system, is in reality a three-wire system at radio frequencies, as shown in Fig. 1, the third conductor being ground. In fact if one neglects the ground circuit, he neglects, as will be shown later, practically the whole radio noise problem. This is true whether the lighting fixture and ballast case are grounded or ungrounded. The noise evaluation scheme presented here considers indirectly the line-to-line circuit, and emphasizes the line-to-ground circuits.

A radio noise meter[3] is useful for indicating the existence of radio influence voltages across various terminals in a fluorescent lighting system. These voltages are caused by the capacitive coupling between the various ballast coils and case. Fig. 2 shows the schematic circuit diagram for a series two lamp ballast. To illustrate how capacitive coupling to case might cause line-to-ground voltages, Fig. 3 shows a crude lumped-constant r-f equivalent circuit for the ballast of Fig. 2. It is not intended to be an accurate description of the r-f circuit. Actually, the circuit varies with frequency and contains inductive as well as capacitive coupling between coils. For the purpose of description, the intercoil capacity and the coil to fixture capacity are assumed to result in a wye connection of three capacitors. However oversimplified this r-f equivalent circuit may be, it does serve to help visualize the effects of grounding various parts of the system. For example, an ungrounded fixture is associated with the ground loop circuit by its capacity to ground. Therefore, grounding the fixture (shorting C_f) may significantly increase the effects of conducted noise because the capacity to ground is short-circuited, decreasing

Full text of paper 56-75 presented at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956, and recommended for publication by the AIEE Committee on Production and Application of Light.

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the loop impedance and resulting in increased r-f currents in the loop. Even though the line-to-ground voltages occur by devious means, they are of primary importance. The ground loop, because it has more area, represents a more effective radiating loop antenna than does the loop between lines. Furthermore, if both line-to-ground voltages are negligible, the line-to-line voltage is automatically negligible, since the sum of the three must equal zero. For these reasons, the test procedure about to be described considers only line-to-ground voltages.

An important stumbling block in a radio influence voltage evaluation of this kind is the variability of the r-f properties of the fluorescent lamps. Five-to-one changes in radio influence voltages in a short period of time may be expected.[3] In comparing different filtering schemes on a given ballast, these variations are not a serious problem as long as the suppression devices can be introduced and removed in such a way that the lamp behavior can be observed at all times. Several trials readily produce a fairly good measurement of the attenuation introduced by the suppression scheme, provided that the lamps have not changed.

Table I. Typical Data of New Lamps as a Function of Time

All data in microvolts, and given as the average of the two line-to-ground readings. The same *96T12* lamps were used throughout these tests

(Tests taken over $^1/_2$ hour or longer intervals)

Test No.	600 Kilocycles				1,000 Kilocycles				1,500 Kilocycles			
	Line A		Line B		Line A		Line B		Line A		Line B	
	Ref.	Test	Ref.	Test	Ref.	Test	Ref.	Test	Ref.	Test	Ref.	Test
1	76	785	31	885	24	240	13	240	17	78	6.5	82
2	117	717	53	1140	43	417	22	453	29	103	10.5	108
3	238	3370	95	5240	87	1220	48	1940	60	285	24	385
4	205	4000	85	4350	57	655	30	750	44	170	15.5	162
5	100	1540	65	1540	53	615	33	665	128	315	52	305
6	700	5740	285	5500	317	2100	165	2100	165	505	73	475
7	445	5640	175	5500	220	1820	110	1890	135	445	59	435

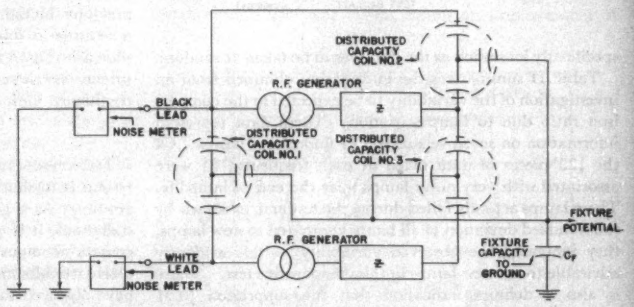

Fig. 3. Descriptive circuit diagram of a series ballast at radio frequencies

When the filtering is built into the ballast, the problem of determining the attenuation is more formidable. One solution is the introduction of a stable noise source to replace the lamps. However, this is a scheme that can yield unrealistic results. If the lamp noise output varies in the laboratory, it will also vary in practice and should be considered. Furthermore, it is difficult to reproduce the characteristics of the lamps exactly. The capacitive and inductive coupling to ballast leads and the fixture should be the same and the variable generated energy and internal impedance of the lamps should be duplicated as they normally occur. All of this is awkward to accomplish or to neglect justifiably especially since neither is necessary. A reasonably successful solution to this problem is to compare the ballast to be evaluated with a reference ballast or condition. This is done by rapidly switching the lamps from reference to test ballast and comparing the line-to-ground voltages. As a comparison figure, the ratio of the average line-to-ground voltages of the two ballasts, expressed in db, is used. Expressed mathematically the comparison ratio in db equals $20 \log_{10} V_T/V_R$, where V_T is the average line-to-ground voltages of the test ballast and V_R is the average line-to-ground voltage of the reference ballast. The average includes readings from both lines to ground. Several sets of reading should be considered for each frequency evaluated. The NEMA (National Electric Manufacturers Association) 600-ohm network[2] or some other reference may be used to simulate the r-f power line impedance.

EVALUATION OF PROBABLE FIELD PERFORMANCE

The variation of the r-f characteristics of fluorescent lamps with time, and between lamps, appears to be nearly random in nature. That it is not purely random was indicated first by the fact that interference complaints could sometimes be solved by replacing old lamps. A study of several lamps over a long period of time was made to evaluate statistically the variation of r-f energy. In this study the system of comparison described was used. The reference ballast had 0.01-microfarad capacitors across each lamp it supplied. The test ballast contained no suppression except for the data summarized as "suppressed" under test condition. All the data was observed about 10 seconds after the lamps were switched from one ballast to the other, in order to avoid transient effects caused by the switching Readings were taken at three frequencies—600; 1,000; and 1,500 kc—to cover the spectrum of commercial amplitude modulated broadcasting frequencies. The data was grouped into two time intervals, a short and a long. The data of Table I is a typical sample of long time intervals. Each of these pieces of data represent the average of three short interval pieces of data. The long interval had a duration of a half hour to two hours. The short interval was about one minute. The long time interval was not stated

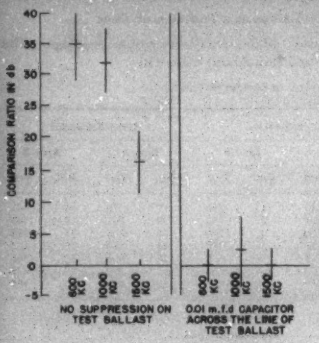

Fig. 4. Comparison evaluation of a 48-inch fluorescent lamp system (with 0.01-microfarad capacitor across each lamp in reference system)

specifically inasmuch as the data was to be taken at random.

Table II summarizes the information obtained from an investigation of the variability to be expected in the comparison ratio due to lamp variation. These data represent information on seven sets of *96T12* fluorescent lamps. Of the 123 pieces of data taken at each frequency, 21 were associated with very noisy lamps near the end of lamp life. These lamps actually failed during the test and, as shown by the standard deviation of all lamps compared to new lamps, they increased the observed variability.[4] It is evidently advisable to use new lamps in this comparative test. There is also a definite indication that the suppressed (0.01 microfarad) lighting system exhibits less variation than the unsuppressed system.

The data of Table II indicates that with a confidence limit of two standard deviations, 95 per cent of all observations taken over a short period of time will fall within ±6.2 db at 600 kc, ± 7.4 db at 1,000 kc, and ±10 db at 1,500 kc of the average comparison ratio with no suppression on the test ballast. However, using an average of five readings taken over a period of one day, the spread expected by chance is ±2.8 db at 600 kc, ±3.3 db at 1,000 kc, and ±4.5 db at 1,500 kc with the same degree of confidence. The lamps are left on for the whole day of testing.

In this way, a comparative test for radio frequency suppression of fluorescent lamps has been made quite accurately. If one can establish a ballast and filtering scheme that has given satisfactory field performance, he can state from the statistical analysis given that any new ballast must have average conducted noise voltages less than 5 db above the selected standard at each of the frequencies mentioned. In fact, it would be fairly safe to require only a 600-kc reading and a maximum ratio of +3 db for a satisfactory limit.

Table II. Statistical Summary of Data on Fluorescent Lamp Variation

Test Condition	Average Ratio in db			Standard Deviation in db		
	600 kc	1,000 kc	1,500 kc	600 kc	1,000 kc	1,500 kc
New Lamps	23.6	22.3	11.5	3.1	3.7	5.0
All Lamps	23.4	23.7	19.0	3.3	5.5	9.9
Suppressed*	−4.2	4.1	2.4	2.2	2.2	4.4

*0.01-microfarad capacitors across each lamp in both the test ballast and the reference ballast. For all other data, only the reference ballast was suppressed with 0.01-microfarad capacitors.

db = 20 $\log_{10} V_T/V_R$

V_T = Average line-to-ground voltages of the test ballast.

V_R = Average line-to-ground voltages of the reference ballast.

Fig. 4 shows a plot of additional data taken on 48-inch fluorescent lamps. The graph on the left compares two similar ballasts, one (the reference) with 0.01-microfarad capacitors across the lamps and the other with no suppression. In the right hand chart, the test ballast has a 0.1-microfarad capacitor across the line. The spread in the short-time readings is indicated by the length of the vertical lines. The average of five of these readings is shown by a short horizontal line. The average data for the test ballast suppressed by a single 0.01-microfarad capacitor across the line falls within the 5-db limit established by the previous investigation. Therefore, the new suppression scheme is in this case adequate. The spread in the data shown in Fig. 4 for short-interval readings falls within the spread for these readings established by the 95 per cent confidence limit of the data of Table II.

CONCLUSIONS

THE APPARENT WAY to filter high-frequency power from a system is to shunt the power through a low impedance to ground. As a general procedure on fluorescent lamp installations, it is questionable. Ground can frequently become a nebulous quantity. Private homes may be particularly troublesome in this respect. All the data the authors have observed suggest that the use of capacitors across the lamps is the most reliable means of internal ballast suppression. For this reason measurements have been made using systems with capacitors across each lamp as references. In addition to reducing and stabilizing conducted noise, capacitors across the lamps may reduce direct radiation from the lamps and fixture by as much as 25 db.

A comparison scheme may successfully fill the present void in general methods of evaluating the conducted noise potential of a fluorescent lamp and ballast system. By the application of elementary statistics, it is possible to make quite effective evaluations. The suggested filtering scheme for the reference is the application of 0.01-microfarad capacitors across each lamp in the system.

In specifying a 5-db limit on the difference between a filtered ballast and a reference ballast, it was assumed that the variance of a filtered system will not be greater than the variance of the unsuppressed system. It has been shown that the filtered variance is sometimes less than the unfiltered ballast. To date greater variance has not been detected.

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Use of Proportional Counters in X-Ray Diffraction

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IN X-RAY DIFFRACTION, the data are obtained by measuring the intensities diffracted at any given angle from a sample. Inasmuch as the intensities to be measured are often extremely low, the Geiger counter has been used as the measuring device because of its great sensitivity. Because of the shortcomings of the Geiger counter, several authors, notably Lang and Knowles, have reported on results with the proportional counter replacing the Geiger tube. They used a cylindrical tube with concentric anode wire, with the X-ray beam entering a side window and passing perpendicular to the axis of the cylinder. In recent work at General Electric, both a tube similar to theirs and also a rectangular tube with an anode grid and parallel plate construction have been used.

A counter tube with quench can be operated either as a Geiger or proportional counter. If the voltage is lowered below the Geiger region, the tube operates as a proportional counter. However, for proportional operation, the quench is not needed. The elimination of the quench renders the tube characteristics independent of temperature a very desirable feature.

The output pulse of a Geiger tube is of the order of a volt, while the pulse from a proportional counter is in the microvolt range. Hence a preamplifier with a gain of about 100,000 was used. In measuring X-ray intensity with a counter tube, the average pulse rate is obtained from a rate meter and the exact number of pulses in a given interval is measured with a scaler. The number of counts per second (cps) is a measure of the X-ray intensity.

To illustrate the counting rates obtainable with a proportional counter as compared to a Geiger tube, consider Fig. 1. Here the log cps is plotted against the number of nickel filters in the X-ray beam. Since the absorption curve is exponential, this relation should be linear. The same tube was operated both as a Geiger and then proportional counter, with results shown in curves 1 and 2 respectively. For Geiger operation the losses are 30 per cent at 10,000 cps, while for proportional operation the losses are only 15 per cent at 100,000 cps, and 1.5 per cent at 10,000 cps. This means an improvement of

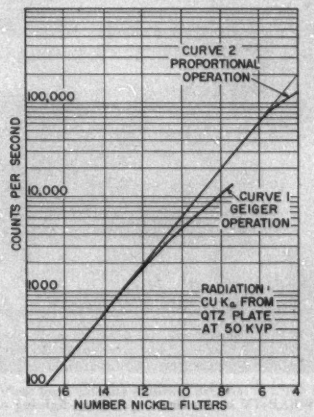

Fig. 1. Intensity calibrations, rectangular tube, argon filled with organic quench

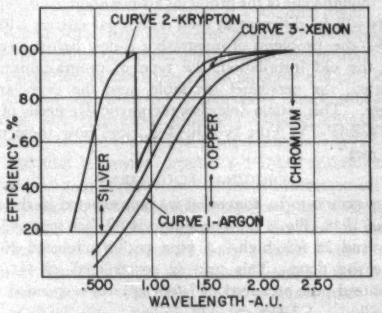

Fig. 2. Efficiency versus wavelength

20 times in reduced losses at 10,000 cps for proportional operation. An important characteristic of counter tubes is their efficiency, meaning the percentage of the X rays converted to counts. In Fig. 2 are shown data on efficiency versus wavelength for two rectangular proportional counters filled with argon and krypton (curves 1 and 2, respectively) and a cylindrical counter filled with xenon (curve 3). The reason for the sharp rise in the krypton curve is the absorption edge for the gas at 0.860 Angstrom units. The krypton tube is about 8 times as efficient for silver radiation as the argon tube.

In summary, the advantages of the proportional counter over the Geiger counter are:

1. At least 1,000 times longer life.
2. Elimination of temperature shift of plateau by elimination of quench.
3. Reduction of losses at 10,000 cps by a factor of 20.
4. Use of a tube which cannot be damaged by overvoltage or excessive X-ray intensity.

Digest of paper 55-739, recommended by the AIEE Committee on Electronics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3-7, 1955. Published in AIEE *Communication and Electronics*, January 1956, pp. 734-6.

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Conversion of Studio Lighting for Color Television

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Station WBAP-TV in Fort Worth has converted its studio lighting to permit color telecasting. The problems encountered and their solutions are outlined.

THE CONVERSION from black-and-white to color television introduces numerous lighting problems. Although some of the problems are common to all stations, others will be different at each individual station; for example, the problems of integrating a new lighting system with the old installation, the type of programming anticipated, the personnel available, and the ever-varying budget. This article describes the particular needs of Station WBAP-TV, Fort Worth, Tex., and how these needs were met.

ORIGINAL EQUIPMENT

THE STUDIO to be converted was constructed in the summer of 1948 (Fig. 1). The studio is 82 feet long, 45 feet wide, and 28 feet high. A pipe grid is mounted 20 feet above the floor. This grid is constructed of $1^1/_4$-inch galvanized pipe arranged in 7-foot squares suspended from the ceiling. A 3-foot catwalk, 14 feet above the floor, runs around the two sides and one end of the studio.

The lighting fixtures and control equipment in use just before the conversion to color were essentially those purchased and installed in Fig. 2. Each fixture contained 12 lamps of which 6 were type *PAR-38* floods and 6 were type *6R-40* floods. Separate circuits were used to supply power to the two types of flood lamps. The *PAR* lamps were used for modeling whereas the *R-40* lamps were used for fill light. Each fixture was designed to permit to adjustment in azimuth and elevation. A 360-degree turn plus tilt adjustments were made by means of cords running to a central location. Similar turn and tilt adjustments were provided for 15 fluorescent fixtures. The fluorescent fixtures each contained six 64-inch slimline tubes. Back light was provided by Fresnel "spots" which were mounted on the catwalk rail. Then 2-kilowatt spots and ten 750-watt spots were in use.

The total wattage from all fixtures amounted to 62 kilowatts, or approximately 18.5 watts per square foot. In 1948 and 1949 it was the practice to provide 200 foot candles for use with the *5655* image orthicon tubes. With the fixtures then available, it was not possible to provide 200 foot candles around the four walls of the studio. However, by means of the turn and tilt controls, the light could be concentrated on any two or three areas in use at any one time. Later, with the development of the more sensitive *5820* image orthicon pickup tube, only 100 foot candles of studio lighting was required. A 100 foot-candle illumination could be provided uniformly for any area in the studio without turning fixtures.

ORIGINAL LIGHTING SWITCHBOARD

THE SWITCHBOARD was designed to handle 140 separate circuits, with 140 silent-type mercury switches being used to control remotely a similar number of relay contactors. Each switch was rated at 10 amperes, and the load contactors handled the load current of 20 amperes. One relay load contactor was used for each load receptacle. Each load circuit was provided with a 20-ampere breaker. The load contactors were fed from two 200-ampere main breakers in the power feed.

Fig. 1. WBAP-TV studio showing original lighting equipment

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With the advent of the type *5820* image orthicon tube there was a lessening of the infrared problem noticeable with the earlier types of pickup tubes. At this stage, a dimmer board of 12-kilowatt capacity was constructed and placed into operation. It was used only by those desiring very special lighting effects, since its operation necessitated the running of extension cables along the grid from the dimmer to the fixture. Therefore, a great deal of ladder work was required for dimmer effects. In fact, the main objection to the control switchboard by the operating personnel was its position on the catwalk 14 feet above the studio floor. The load contactors were subject to sticking, thus leaving the circuit continually hot until someone filed or replaced the contact points. Fig. 3 shows the location of the original switchboard on the catwalk.

AIR CONDITIONING

As IT IS WELL KNOWN, the summers of Texas are not noted for being mild. One of the first problems at WBAP-TV was the disposal of the additional heat to be generated by the increased lighting load. A heat exchanger was built on the roof of an adjoining building with connecting ducts feeding into one end of the studio. Two 100-ton compressor units were already in use. One 60-ton compressor unit was added to the existing chilled-water lines which were extended to the new heat exhaust. Additional ducts were added above the grid in the studio. The new studio air-conditioning capacity was almost doubled over that of the existing installation.

PRIMARY POWER

THE SUBSTATION in use in 1954 belonged to the Texas Electric Service Company and had a 450-kva capacity. The three transformers in use were purchased from that company. Three similar 150-kva transformers were added to the transformer bank to give a total of 900-kva installed capacity. The total load was not expected to be doubled, but it was felt that the reserve power capacity would suffice for possible future needs. When the new transformers were installed, the complete substation was purchased from Texas Electric. It appeared to be an economical move to purchase the substation since the saving in power costs would pay for the transformers within approximately six years.

In the basement power vault, a new 150-kva transformer was added to the secondary bus. Fortunately, there was space to fit the new transformer in the same room with two similar 150-kva transformers already in use. The new transformer feeds 120–208 volt, 3-phase, 4-wire service to a 400-ampere main breaker. The second transformer feeds two 200-ampere breakers, one of which is the main for lighting in another television studio.

The utility furnishes primary power on its lines to the property line where it is metered at a common point. Then by WBAP lines, primary power is sent to the transmitter building for air conditioning and transmitter power. From the substation at the main building, service is provided to to the air conditioning compressors, heat exchangers, motors, and equipment requiring 440-volt service. The secondary bus feeds a 50-kva transformer serving the building and film laboratory needs; a 100-kva transformer for radio studio equipment; a 150-kva transformer for regulated power to the television equipment; a 150-kva transformer serving a 200-ampere main breaker to studio 2 lighting; and a 200-ampere main breaker to the studio 1 dimmer circuit. There are twelve 50-ampere sub-breakers on this circuit. The last 150-kva transformer on the secondary bus feeds the 120–208 volt, 3-phase, 4-wire service to the nondim circuit on the switchboard in studio No. 1. There are, of course, many other circuits fed from the secondary bus transformers; for instance, a circuit to provide power to the remote truck for adjusting equipment while the truck is parked in the garage.

Fig. 2. View from catwalk showing original lighting equipment

NEW LIGHTING SWITCHBOARD

THE NEW STUDIO SWITCHBOARD has a capacity of 1,800 amperes. The nondim circuit contains 400-ampere main fuses and a main switch. There are twelve 100-ampere sub-breakers. The dim circuit contains 200-ampere main fuses and a main switch. There are twelve 50-ampere sub-breakers each feeding a 55-kw Ward Leonard Autrastat dimmer. Master and submaster dimmer control handles are provided.

"Rotolector" switches are used in the new switchboard. A rotolector switch is a convenient means of cross-connecting a load circuit to any supply circuit. Twenty-four

Fig. 3 (left). Original switchboard. Fig. 4 (right). New switchboard, showing dimmers at left, rotolector switches at right

rotolectors are used—corresponding to the 24 subcircuits—12 dim and 12 nondim. In all, there are 140 20-ampere and ten 50-ampere units, each with a breaker and pilot light. Twelve ammeters across the top meter the dimmer circuits to allow the operator to load the dimmers to their full capacity. The switchboard and rotolectors are on a platform elevated 3 feet above the studio floor. The valuable studio floor space lost is offset by the convenience of a nearby location (Fig. 4). A tremendous saving in power has been realized from this new location. With the new lighting load it would be a great waste to have nonessential lamps burning. The new switchboard location makes it practical to keep the lights off unless in actual use. The turn and tilt controls were moved with the switching to the platform.

LOAD CIRCUITS

Under the old system the load circuits were fed from the relay contactors into the studio in 4-inch square ducts with hinged covers. There was a total of 120 twist-lock receptacles in connecting boxes. Fortunately, there was plenty of space in these ducts to accommodate additional wiring. The load wire to each receptacle was disconnected from its relay terminal, lengthened, and connected to its proper rotolector terminal, thus utilizing most of the existing wiring and all of the existing receptacles. Under the old system a separate neutral wire was connected to three receptacles. It was necessary to add neutrals so that the neutral of each receptacle was individually fed back to the rotolector board. Twenty additional 20-ampere twist lock and ten 50-ampere pin type receptacles were added to these ducts above the grid.

NEW FIXTURES

The 18 Television Associates incandescent banks in use since 1948 were retained. These continued to use both *PAR-38* and *R-40* type lamps on separate circuits and retained their turn and tilt controls. The 15 slimline fluorescent fixtures were taken down—not because of any adverse experience with the light quality, but because of their physical size and space limitations (Fig. 5). Fifty 18-inch scoops were added, each using 2-kw clear *PS-52* general service lamps. Eighteen scoops were hung on individual pantagraphs. To make it possible to lower these scoops to eye level the pantagraphs were installed on a 1-inch pipe grid suspended 3 feet below the permanent grid. The remaining 32 scoops were hung on pendant clamps with a 4-foot height adjustment. These in turn were hung in pairs from turning spindles similar to the turning devices on the Television Associates telelights. These we made up from spare parts and 3/4-inch pipe. Thirty 8-inch Fresnel spots were added for back

Fig. 5. New lighting layout, showing switchboard at right

and key lighting. Two-kilowatt *G-48* mogul bipost lamps are being used in these spots. For special effects, five 16-inch Fresnel spots using 5-kilowatt mogul bipost lamps were added. For similar use, six 6-inch strips each containing twelve 150 watt *R-40* spat lamps; two 750 watt boom lights; and two 8-inch, 2-kilowatt pattern projectors were added. There is now 60 watts per square foot as compared with 18.5 previously used. (See Fig. 6).

Fig. 6. New lighting layout

CONSIDERATIONS

THERE WERE SEVERAL considerations which prompted the types and number of fixtures, the control equipment, and the method of installation. First, it was not economically feasible to scrap the investment in the telelight incandescent 12 lamp banks. Although these fixtures are old and the light output not as controllable as sometimes might be desired, they do put out a large quantity of light, one of the essentials for color lighting. Therefore, the first consideration was the integration of the incandescent fixtures at least, if not the fluorescent fixtures, with the new lighting system.

The second consideration was the programming. It was planned to start from the first with $5^1/_2$ hours per week of live studio programs. This made it advisable to provide one end and one side of the studio with 400 foot candles of light at any one time. Further, it was considered desirable to be able to swing the light quickly from one side of the studio to the other during a program. It works this way in actual practice: Scene 1 is along the west wall—when scene 2 is on the air from the south end of the studio, the lights can be readjusted from the west side over to scene 3 along the east wall, by one man. This leads to the third consideration—that no additional personnel would be added to the staff to take care of the lighting. One man is responsible for the lighting and lighting equipment maintenance. This man has other duties, but before and during the color shows he devotes his entire time to lighting. This is the reason as many fixtures as possible have turn and tilt adjustments controllable from a central location.

The next consideration involved accurate intensity control. It was desired to light all sets with a uniform light level of 400 foot candles plus or minus no more than 25 foot candles. Lighting effects, particularly those involving dimming, have always been important to this station and it was desired to continue or even expand the use of effects. To make the lighting as uniform as possible as well as make possible any effects the directors would like to try, the rotolector board and the dimmers were included in the plans. A new control system was necessary in any case, it was physically impossible to expand the old switchboard and relay system to carry the additional load, even if anyone had desired to continue the old system.

An extremely important consideration was the budget. The management was, of course, willing to spend the amount necessary to provide a good color picture. Some effects fall under this category, but large numbers of fancy gadgets and accessories do not.

We are never completely satisfied with what we have—there are always new things on the market, or changes, or expansions to consider. As soon as funds are available, plans call for conversion of another studio, 30 by 40 feet, from black and white to color, as well as additional spots for use as back light in the large studio and possibly subsequent conversion to pin-type cable connectors.

Cigarette Lighters Ordered for USAF

The common auto dashboard cigarette lighter has invaded the realm of electronic warfare, as a built-in part of a complex new ground-based United States Air Force air defense system in development here.

The lighter has a distinctly scientific purpose in the complex, classified electronic equipment being built under a multimillion-dollar contract by General Electric's heavy military electronic equipment department.

Engineers say an operator, scanning the system's glowing indicator radar scopes for hours in semidarkness, could be temporarily blinded by the flare of a match or pocket lighter when lighting a cigarette. Furthermore, his hands must be free to work the dozens of knobs, switches and buttons on the control panel.

Accordingly, the built-in lighter was ordered as part of a "human engineering" program, to keep the operator as undistracted as possible.

A Modern D-C Network Analyzer

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THE D-C NETWORK ANALYZER described is a new version of a device which, although it has been utilized for 40 years, is still useful. The d-c network analyzer has three important advantages over the a-c network analyzer, which it resembles:

1. Solutions are obtained more rapidly.
2. Less training is required for operating personnel.
3. The equipment is considerably less expensive.

These advantages are a result of the inherent simplicity of scalar representation of an a-c circuit. Although this simplicity is obtained with some loss in accuracy, experience shows that the results are entirely satisfactory for many power-flow and short-circuit problems. A modern d-c network analyzer costs about a tenth as much as an a-c network analyzer with the same number of line units. Thus both an a-c network analyzer and a d-c network analyzer can be made available for a relatively small increment over the cost of the a-c analyzer only. Co-ordinated use of the two analyzers will produce about twice the useful results of either one alone.

The new analyzer consists of two self-contained sections, one of which is shown in Fig. 1. Each master console contains 150 line units, 25 constant-current load units, the instruments, the unit-selection switches, a ground-point selection panel, and the power supplies. Each connection unit contains the terminating plugs of the corresponding line and load units, 750 jacks for forming these units into the network to be studied, 50 jacks representing generators, and 30 ground jacks. The ground jacks are connected through two switches (15 to each switch) by means of which they can be disconnected from each other and from ground. Each connection unit also has 10 jumpers, which can be keyed to the instruments, and 20 tie busses, which terminate on the connection unit of the other section.

Fig. 1. One section of d-c network analyzer showing master console and connection unit

The most unusual feature of the analyzer is the relatively small voltage and current bases adopted, 20 volts and 0.2 milliamperes. This feature tends to minimize size, weight, and heat dissipation. It also makes possible a self-protecting analyzer, without the necessity of having fixed resistors in series with the jacks representing generators.

The problem of measuring the small voltages and currents chosen was solved by the use of a rugged microammeter of 1/4-per-cent accuracy. The movement employs no jewel supports, the bobbin being suspended by a pair of bifilar wires at each end. The lack of friction results in a movement that requires low power for its operation, even with high speed of response. Consequently a low-resistance microammeter and a high-resistance voltmeter are possible.

The low base current and voltage make possible the use of compact rheostats for line units. Although these units have nominally a 1-per-cent tolerance, very few units actually use the full tolerance. The small size of the line units makes it possible to array 150 3-decade units within easy reach of the operator.

The constant-current load units, which consist of a highly degenerated triode with a variable grid bias, are an important means of speeding up load-flow studies. These units maintain current within 0.2 per cent throughout a load bus voltage range from 50 to 150 per cent.

A major innovation is the use of a separate grounding panel, located on the master console. One end of each unit is internally connected to the panel. By plugging the ground cord on the master console into the proper jack, a ground on any point in the system can be obtained, thus simplifying short-circuit studies. The grounding panel and voltage-difference cord are used to measure the voltage difference between any two points in the network.

Each unit is connected to the instrument system by means of a telephone-type lever key switch, each switch being associated with a line or load unit. In addition to providing for the measurement of voltages and currents through out the network, the instrumentation is so arranged that the ammeter can be switched to indicate directly individual circuit breaker duties.

The main power supply is designed to eliminate the frequent adjustments ordinarily required by changes in fault location or by other changes in system parameters. Measurements at 100 per-cent voltage show a regulation from 0 to 10,000 per-cent load of 0.04 per cent and an 8-hour drift of ± 0.025 per cent. Analyzer operation has been very satisfactory, with an over-all error of less than 1.5 per cent.

Digest of paper 56-20, recommended by the AIEE Committee on Computing Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

C. H. Hoffman is with Public Service Electric and Gas Company, Newark, N. J., and M. Lebenbaum is with Airborne Instrument Laboratories, Inc., Mineola, N. Y.

Sequence Impedances of Transformer Connections

B. A. COGBILL
FELLOW AIEE

IN THE GENERAL APPLICATION of the method of symmetrical components to the solution of 3-phase problems, 3-phase circuits are resolved into three single-phase circuits, one for each of the sequences, positive, negative, and zero.

Sequence circuits of 3-phase transformer connections are usually derived by making full use of concepts which have been developed from a single-phase point of view. Such procedure has been found to yield correct results in all of the more common cases. Therefore, there is a strong temptation to generalize by assuming that the procedure is applicable to all 3-phase transformer connections. To make such an assumption, however, is a mistake and can lead to incorrect results; the concept that all mutual impedances are bilateral, which allows the single-phase problem to be greatly and beautifully simplified, is not completely applicable to the derivation of the sequence circuits of all 3-phase transformer connections. Apparently, this fact and its implications are not generally recognized.

Shown diagrammatically in Fig. 1 are the terminals of a 3-phase multicircuit transformer connection having any number of terminal sets, each of which consists of three line terminals and a neutral terminal. The diagram is not intended to give any hint as to how the transformer windings are connected. In fact, the cores and coils may be constructed, arranged, and connected in any conceivable manner provided that

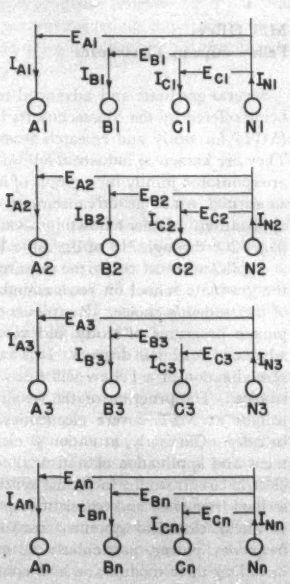

Fig. 1. Terminals of multicircuit 3-phase transformer connections

1. Positive- and negative-sequence magnetizing currents can be assumed to be negligible.
2. There are no internal short circuits to positive- and negative-sequence currents.
3. The connection possesses 3-phase symmetry which is defined as follows: A system of impedances possesses 3-phase symmetry if positive-sequence current in the system or any part thereof produces only positive-sequence potential differences between any two points of the system; negative-sequence current produces only negative-sequence potential differences; and zero-sequence current produces only zero-sequence potential differences.

The criteria for 3-phase symmetry can be completely expressed in the form of the equations

$$Z_{AhAk} = Z_{BhBk} = Z_{ChCk}$$

$$Z_{AhBk} = Z_{BhCk} = Z_{ChAk}$$

$$Z_{AhCk} = Z_{BhAk} = Z_{ChBk}$$

in which Z_{AhAk} is the mutual impedance between the internal circuit which connects terminal Ah to Nh and the internal circuit which connects Ak to Nk. Similarly, Z_{AhBk} is the mutual impedance between circuits Ah to Nh and Bk to Nk, etc. If $h = k$, Z_{AhAk} becomes Z_{AhAh}, which is the self impedance of the circuit Ah to Nh; h and k are general general terminal set identification subscripts. They may be $1, 2, 3 \ldots n$.

The theoretical analysis based on the general connection of Fig. 1 and the three assumptions listed leads to a number of conclusions among which are:

1. In general, the necessary and sufficient number of independent impedances required for specification of the positive- or negative-sequence impedance characteristics of a symmetrical 3-phase transformer connection is $(n - 1)^2$, where n is the number of terminal sets.
2. For zero-sequence, the necessary and sufficient number of impedances is $n(n + 1)/2$.
3. Single-phase impedance tests between all possible pairs of terminal sets will not, in general, give sufficient information for specification of the positive-sequence impedance characteristics of a multicircuit transformer connection.
4. It is possible that multicircuit transformers with phase interconnections may not operate satisfactorily in parallel even though all of the usual criteria for satisfactory parallel operation of transformers are satisfied perfectly.

Digest of paper 55-671, "Sequence Impedances of Symmetrical 3-Phase Transformer Connections," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, February 1956.

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NOTES IN EDUCATIONAL CIRCLES

Article on the Challenge of Prize Papers

The following article by L. A. Rubin entitled "Prize Paper Contest" was in the December 1954 issue of the *Moore School Record*. This is a publication by the electrical engineering students of the University of Pennsylvania.

Each year, the Moore School Joint Student Branch of the AIEE and Institute of Radio Engineers (IRE) encourages every student to participate in the Prize Paper Contest. Up to now participation has been very poor, although many people have tried to help students get started and have encouraged them to investigate a subject which would lend itself to a fine paper. These people are, as always, ready to help the student select a project, find space to do the research, and finally, help him write his paper. They will not do the work for the student.

Writing a paper does not necessarily require laboratory work. In fact, the paper does not have to be about an original subject but may be about a subject done a thousand times before. The only requirement is that the approach be novel and fresh. There are many subjects which one may want clarified. The student should study one such subject at length and then write a paper on it, making it the shortest, most coherent, well-organized paper possible. This may take a dozen or so rewrite attempts. But it is worth all the trouble because the experience of writing such a paper and presenting it to a class is extremely valuable. Prospective employers and others in the field will be interested in activities of this nature.

There are many minor research projects available. The student's advisor will be able to help him find one or to direct him to someone else. If he really gets lost and can find no one to help him, he may contact Dr. E. I. Hawthorne at the Moore School of Engineering, University of Pennsylvania, Philadelphia 4, Pa. Dr. Hawthorne will help the student in respect to writing the paper, doing the research, or even finding a good topic.

The importance of writing a paper of the nature described cannot be overemphasized. Industrial concerns today require their engineers to deliver their papers in front of the assembled staff as a time-saving expedient. Sooner or later one must learn to write a good, presentable research paper. It might just as well be done several times under the easiest and least painful conditions available for this sort of thing. Fellow students and instructors are much more sympathetic to shortcomings than an employer.

In presenting the paper, it might be helpful to prepare graphs, illustrations, diagrams, etc., on slides so that the presentation will be complete. The previously mentioned people will be glad to help with these, too.

The competition in the Moore School was held the week of February 14. The winning paper will be eligible for the AIEE regional contest in Ohio in March. More details will be available for that event.

SMPTE Committee To Compile Report on Courses of Instruction

Formal steps have been taken by the Society of Motion Picture and Television Engineers (SMPTE) to compile a report on motion picture and television instruction in colleges and universities in the United States. Dr. J. G. Frayne, president of the Society, announced that he had appointed a Committee on College Motion Picture and Television Curricula which would begin work on this project at once.

In 1946, Dr. Frayne compiled a report on motion picture instruction in colleges and universities and, in September 1950, this report was revised by Jack Morrison of the University of California at Los Angeles. In addition to bringing those earlier reports up to date the committee hopes to expand them to include related courses in television instruction.

The committee, under the chairmanship of D. P. Wedberg, editor of Film and A-V World, is a subcommittee of the Society's Committee on Education. The parent group was organized early in 1955 to meet the growing need for trained technical people in the motion picture industry. Through its subcommittee on Training of Film Laboratory Technicians, the group has already established three seminars at the Engineering Extension Division of the University of California at Los Angeles.

MIT Offers Fellowships in Electronics

Several graduate and advanced research fellowships are being offered by the Massachusetts Institute of Technology (MIT) for study and research in the field of electronics. They are known as industrial fellowships in electronics and are sponsored jointly by a group of industrial organizations concerned with the advancement of electronics and its applications. Other fellowships available may be found on pages 208 through 210 of the June 1955, MIT catalogue.

Applicants must satisfy the requirements for admission to the graduate school on recommendation of a department of the student's choice. Recipients of such fellowships will pursue programs of study and research leading towards advanced academic degrees. It is expected that the area of specialization of a Fellow will fall within the field of electronics. The program of the research laboratory of electronics at MIT covers electronics and its applications broadly. Currently, attention is centered on the development and application of statistical communication theory; electric circuit studies including synthesis of circuits for prescribed frequency and transient response; optimum design of linear electrical systems; useful generators of radio-frequency power, particularly at microwave frequencies, including their modulation and control and studies of the

theory of their operation; research on basic components and techniques, including circuits and instrumentation; radio-frequency spectroscopy including molecular beam research and nuclear resonance absorption and, in general, the interaction of electromagnetic field with solids, liquids, and gases; research in physical electronics, including electron emission studies, and properties of phosphors; and physical research at low temperatures, including superconductivity at microwave frequencies, and the properties of liquid helium.

There will be awarded a few advanced research fellowships to candidates possessing the doctor of philosophy degree or its equivalent who without enrolling as graduate students wish to pursue advanced studies and research in the field of electronics at MIT.

The stipend of a graduate student fellowship will be between $1,500 and $2,400, for the academic year (9 months) according to experience and qualifications. In addition, tuition fees will be paid for the Fellow. The stipend for an advanced research fellowship will range from $3,000 upward, according to the qualifications of the recipient.

Applicants for an industrial fellowship in electronics should communicate with the Director, Research Laboratory of Electronics. Application should be made at least four months prior to the intended date of entrance. The granting of a fellowship implies no commitment as to its renewal. Fellows applying for reappointment will be judged along with other applicants on the basis of their previous attainments.

A limited number of positions as research assistant in an academic department but assigned to the research laboratory of electronics are available. Students so employed work on research projects in the laboratory and have an opportunity to pursue a graduate program on a part-time basis. Further information regarding these positions can be obtained from the Director, Research Laboratory of Electronics.

District 2 Prize Winners
To Inspect PP and L Facilities

An expense-free trip to Pennsylvania Power and Light (PP and L) Company properties has been arranged for the three top prize winning students in the annual AIEE District 2 prize paper competition to be held at Carnegie Institute of Technology on April 27 and 28. The Central Eastern Pennsylvania utility will play host to the students and their counselors May 10 and 11.

According to PP and L, the visit will afford these outstanding electrical engineering undergraduates an opportunity to catch a behind-the-scenes glimpse of a modern electric utility in operation. The 2-day program will include inspection of the company's newly modernized general office building at Allentown, several substations, and a tour of PP and L's "outdoor type" Martins Creek steam electric station located along the Delaware River. This power plant has an effective capacity of 160,000 kw.

All of the 741 student-members in the 21 AIEE college branches in District 2 are eligible to enter the preliminary competition. However, only one winner will be selected to represent each school in the final competition at Carnegie Tech. From these 21 will be chosen the three winners who will be invited to make the PP and L tour.

TOUR STOP. One of the points of interest in the tour of PP and L Company facilities will be the Martins Creek steam electric station.

Accompanying the students and their counselors will be A. P. Powell, professor of electrical engineering at Pennsylvania State University and AIEE District 2 chairman of student activities and C. T. Pearce, District 2 vice president and regional engineering and service manager for Westinghouse in Philadelphia.

Display Boards Exhibit
Transformer Components

Electrical engineering students in approximately 30 colleges and universities around the country are being acquainted with transformer components through display boards supplied by Allis-Chalmers Pittsburgh Works. The sturdy plywood panels, 4 by 8 feet in size, have mounted on them samples of cable, insulation, gaskets, tap changers, bushings, tapes, etc. In addition they carry photographs showing interior and exterior views of various types of trans-

TRANSFORMER Components Display Board.

Student Branches at Oregon State College

MEMBERS OF THE GRADUATING CLASS in electrical engineering and the faculty advisors of the Student Branches of AIEE and the Institute of Radio Engineers at Oregon State College, Corvallis, Ore. The senior class celebrated reaching the 100 per cent goal in membership in the engineering societies.

formers with information concerning their use in the electrical system. Here four students of the University of Pennsylvania, Moore School of Electrical Engineering, study parts on the display board located at the school.

Student Branch Report from the University of Southern California

The University of Southern California's Student Branch meets every other Wednesday at noon for one hour. Students are invited to bring their lunches, and the Branch serves free coffee and doughnuts. Eight or nine meetings and three or four field trips per semester are held. No dues are charged.

Although there are 66 AIEE and 56 Institute of Radio Engineers (IRE) members (some affiliated with both groups), only about 40 students attend the meetings. It was thought that this small attendance was due to a lack of publicity, as only "dittoed" meeting announcements had been used. Through the co-operation of the Lockheed Missile Division this semester, two-color reusable posters were obtained and placed not only in the engineering building, but also in all parts of the campus. A 3- by 4-foot bulletin board is maintained in the lobby of the engineering building, and a 3-color announcement is kept there with notices of semester meetings. Branch officers distribute literature and application blanks to the classrooms, and next semester these forms will be mailed to all new students.

A DEMONSTRATED LECTURE by Fred Ireland of the General Radio Company on "New Techniques in Measurements" was presented for the members of the Joint Student Branch at the University of Southern California in November. Mr. Ireland is shown demonstrating an elementary computer.

Second Night Meeting Held for New York University Branch

New York University's evening division of AIEE-Institute of Radio Engineers (IRE) Branch held their second "midnight" meeting of the 1955–56 academic year in November. Monthly Branch meetings are held from 10:30 to 11:30 p.m., followed by a social hour until 1 a.m. because many students have full-time employment during the day and attend classes most evenings until 10:10 p.m., but want to maintain an active AIEE-IRE Branch.

MEMBERS OF THE EVENING DIVISION of New York University's AIEE-IRE Student Branch who attended the November meeting.

At the November Meeting, 69 evening engineering students heard E. E. Sumner of Bell Telephone Laboratories discuss the physical and electrical aspects of the transistor, and its basic advantages and disadvantages over vacuum tubes.

INSTITUTE ACTIVITIES

South West District Meeting Scheduled for Dallas, Tex., in April

DALLAS AND FORT WORTH, TEX., will be hosts to the South West District Meeting, April 2, 3, and 4. Inasmuch as the Dallas-Fort Worth area is the second largest aircraft producing area in the United States, it is particularly fitting that "Electricity in Aircraft" be the theme of the Dallas meeting.

Dallas has a population of 750,000. It is the number-one fashion and apparel manufacturing center of the Southwest, has more bank deposits than any city in the South or Southwest, and is the foremost wholesale distribution center of that region.

The Program

A varied program has been arranged offering a wide choice of sessions on aircraft and aircraft applications, power generation, transmission and distribution, communications, management, and industry applications.

For the engineer interested in aircraft, there will be a complete schedule of aircraft technical sessions. Of special interest will be 60 exhibit booths by 44 different exhibitors displaying the latest airborne electrical apparatus, components, and support items. This is the first time in the history of the AIEE that exhibits have been an attraction at a district meeting.

For the electric utility engineer, the power generation technical sessions will place emphasis on new developments and new innovations in nuclear power and turbine and generator designs. The transmission and distribution sessions will place emphasis on insulation co-ordination and lightning arrester characteristics. The industrial groups will place their emphasis on electrical inspection and planned electrical expansion.

A special feature of the program will be a full session devoted to management. One of the Southwest's outstanding electric utility executives will present a panel of three industry presidents who will discuss this timely subject.

The number of papers per technical session has been limited so that each author may present his paper in full, yet allow some time for discussion.

Entertainment

Tuesday evening there will be an informal dinner dance in the Baker Hotel. The affair is planned with an outstanding name orchestra and a floor show of top flight entertainers. Tickets for this event are $5.

"Cinerama Holiday" will be playing during the meeting and Theater '56 is to be open, as well. Also, the Republic National Bank of Dallas, tallest building in the Southwest, may be visited.

For those who desire to play golf, arrangements will be made at any one of the beautiful country clubs in the Dallas vicinity. Be sure to indicate on the advanced registration card if you wish to play golf.

Ladies' Entertainment

A suite for informal gatherings of the ladies will be available during the entire Meeting at the Baker Hotel. A door prize will be given each morning when coffee is served. Cards and tables will be provided for bridge and canasta. The ladies are cordially invited to use these facilities throughout the Meeting. Hostesses will be available to help arrange sight-seeing and shopping tours, or other activities.

Monday morning the ladies will be entertained at a "Get Acquainted Coffee" at the new Statler Hilton Hotel. A door prize will be given. There is no charge for participation in this activity.

On Tuesday morning a brunch and fashion show is planned in the Zodiac Room at the Neiman-Marcus Department store. Door prizes will be given to the lucky ticket holders. The price for brunch is $1.75.

Wednesday morning the ladies will travel by bus to the Dallas Athletic Club Country Club for a book review and luncheon. After luncheon, the chartered buses will take the ladies on a tour of Dallas. The price of the luncheon is $2.75 and the tour and round trip bus fare is $1.25.

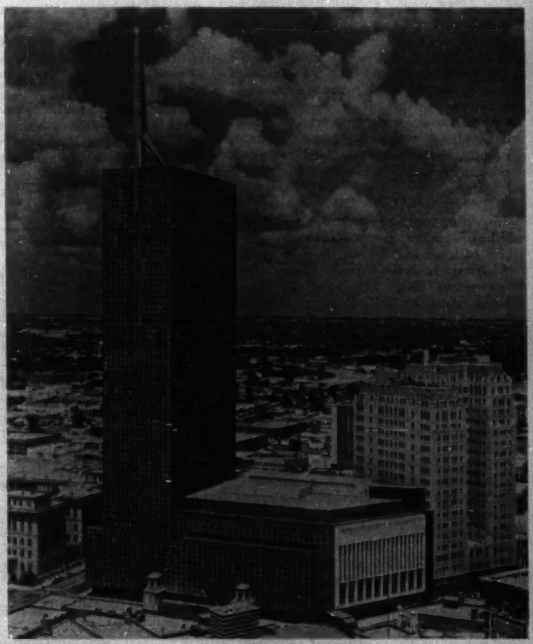
Please indicate on the advanced registration cards the activities you would attend.

Meeting of Board of Directors

A meeting of the board of directors of the Institute will be held Tuesday, April 3, followed by a luncheon.

Student Program

The student program will consist of the District 7 Student Branch Paper Competition



THE REPUBLIC NATIONAL BANK of Dallas has 36 stories above ground and four stories below. The Beacon Light of almost one-half billion candle power is visible from a distance of 120 miles.

VIEW OF THE CITY of Dallas and the Cotton Bowl.

which will be held on Monday and Tuesday.

Of special interest to the students will be a Tea Dance in the Student Center on the Southern Methodist University Campus on Tuesday.

Special arrangements have been made with the Baker and Adolphus Hotels for the housing of students. There is a minimum of four to five students to a room at a rate of $3 per day per student. If you have not made your reservations with your Student Counsellor, please make hotel arrangements promptly, direct with the hotel preferred, specifically referring to the AIEE meeting.

Inspection Trips

Inspection trips have been arranged which will be of considerable interest to all visitors. These trips are as follows: Tuesday morning, April 3, Bell Aircraft Corporation; Southwestern Bell Telephone Company Haskell Avenue Toll Center; Tuesday afternoon, April 3, Chance Vought Aircraft, Inc.; Republic National Bank Building; Wednesday morning, April 4, Texas Instruments, Inc.; Dallas Power and Light Company Parkdale Power Plant.

At Bell Aircraft, the most famous of the models is the Model *47* Helicopter used extensively by all branches of our armed services.

The nine-story Southwestern Bell Toll Center is the second largest long-distance switching center in the United States.

The latest jet news concerning the Chance Vought Aircraft Company is the Navy's granting of a $100 million contract to produce the *F8U-1* jet Crusader which company officials describe as the world's fastest Navy fighter.

Texas Instruments is well known in the electronic industry for its progress in the development and production of transistors, tiny and durable substitutes for vacuum tubes. This company is also an important producer of electronic components such as transformers, resistors, capacitors, and delay lines.

The Dallas Power and Light Company Parkdale Power Plant is a modern outdoor type plant with two units in service with a generating capability of 202,000 kw. Construction of a third unit which will be capable of producing 125,000 kw is well under way and will go on in 1957.

Transportation for the inspection trips will be $1 per person for each trip taken with the exception of the Republic National Bank which is within walking distance of the Meeting.

Please indicate on the advanced registration card the inspection trips you will attend. If insufficient interest in one or more of the trips is indicated by advanced registration, the trips will be cancelled.

Hotel Reservations

Reservations are to be made directly with the hotels, pointing out attendance at the AIEE meeting. Please do not write to more than one hotel. Ask the hotel to confirm your reservation. If your request cannot be filled, the hotel will automatically refer your request to the chairman, Hotels Committee, who will obtain a similar reservation at another of the hotels. Reservations will be confirmed to you directly.

The Baker Hotel has been designated as Headquarters for the Meeting. However, some of the activities will take place at the Adolphus Hotel located across the street. Blocks of rooms have been set aside at the following hotels with rates as indicated.

Baker Hotel (meeting headquarters)

Single room	$ 5.00 to $11.00
Double room	7.00 to 11.50
Twin bedroom	8.50 to 14.00
Parlor suite	23.00 and up

Adolphus Hotel (also used for meetings)

Single room	$ 5.00 to $10.00
Double room	8.00 to 13.00
Twin bedroom	8.00 to 13.00
Parlor suite	20.00 to 25.00

Statler Hilton Hotel

Single room	$ 7.00 to $13.00
Double room	10.50 and up
Twin bedroom	12.00 and up
Parlor suite	20.00 and up

For members attending this meeting who prefer to stay at a motel, a few are listed as follows:

Belmont Motor Hotel, 901 Fort Worth Avenue

Dallasite Motor Hotel, 4126 N. Central Expressway

NEW PREPRINT PRICES

40¢ to Members

80¢ to Nonmembers

MINIMUM ORDER by mail $1.20 unless accompanied by remittance or coupons. All nonmember orders *must* be accompanied by remittance.

COUPON BOOKS in ten-dollar denominations may be purchased.

NUMBERED PAPERS only are available.

SEND ORDER and remittance to:

AIEE Order Department
33 West 39th Street,
New York 18, N. Y.

MODEL 47G HELICOPTER (U. S. Army and Air Force H-13; U. S. Navy and Marine Corps HTL), latest Bell Aircraft 47 series, has logged upwards of a million flight hours.

Eastern Hills Motel, 3422 Samuells Blvd.
Lido Hotel Courts, Highways 67 and 80, near Loop 12.
Tower Hotel Courts, 10108 Harry Hines Blvd.

No rooms at the motels have been set aside for this meeting.

Registration Fees

The difference between member and nonmember registration fees will be rebated to nonmember registrants who file applications within 30 days after the meeting, provided the applications are accepted. The fees are as follows:

Members	$3
Nonmembers	$5
Student Members	None
Families of Members	None

The Committee

The members of the District Meeting Committee are: S. M. Sharp, vice-president District 7; G. A. Smith, Jr., general chairman; P. S. Neblett, vice-chairman; O. S. Hockaday, vice-chairman; John Hutchison, vice-chairman; E. B. Robertson, vice-chairman; C. A. Maas, vice-chairman; J. B. Robuck, secretary; J. L. Pratt, chairman, finance committee; P. G. Wallace, chairman, program committee; Felix Quirino, vice program chairman, aircraft; G. A. Dyer, vice program chairman, communications; Wendell Fowler, vice program chairman, utilities; R. D. Ledbetter, vice program chairman, utilities; J. R. Duff, chairman, exhibits; J. C. Bibbs, vice-chairman, exhibits; H. L. Reynolds, chairman, hotels committee; C. F. Crandell, chairman, registration committee; E. C. Wise, chairman, transportation committee; Curtis Musgrove, chairman, dinner dance committee; L. J. Blaize, cochairman, inspection trips committee; E. W. Rogers, cochairman, inspection trips committee; Mrs. E. C. Thompson, chairman, ladies' committee; R. T. Martin, chairman, publicity committee; F. W. Tatum, chairman, students committee; Floyd McKenna, chairman, luncheon committee; John Sandlin, chairman, sports committee; George Pingree, chairman, reception committee.

Tentative Technical Program
AIEE South West District Meeting

Monday, April 2

8:00 a.m. Registration

10:00 a.m. Transmission

Presiding: P. S. Neblett

DP Lightning Protection of H-Frame Transmission Lines Using One Expulsion Protector Tube per Structure. *J. F. Longley*, West Texas Utilities Company

DP A Unique Design for 230-Kv Wood Pole Transmission Line. *C. W. Gragg, H. N. Wright*, Southwestern Public Service Company

DP56-433 Mutual Sequence Impedances of Parallel Transmission Lines. *W. J. McKune*, Georgia Institute of Technology

Distribution

Presiding: John Barron

DP Use of Synthetic Resin in Splicing and Terminating Power Cables. *W. A. Parker*, Oklahoma Gas and Electric Company

DP Capacitor Switching to Control System Reactive. *V. D. Weber*, Oklahoma Gas and Electric Company

Industrial

Presiding: F. S. Glaza

CP56-14 Electrical Inspection of Petrochemical Plant Construction. *N. D. Casdorph, J. H. Wisting*, Carbide and Carbon Chemicals Company (Previously presented at the Winter General Meeting)

DP A Planned Electrical Expansion. *E. G. Parrish*, Crossett Paper Mill; *J. R. Seeby*, Westinghouse Electric Corporation

Student Session

Aircraft Technical Session—Power Generation

Presiding: Felix Quirino

56-434 Development of Definitions for Voltage Modulation Characteristics in 380 to 420 Cps Aircraft Electric Systems. *Oscar Markowitz*, U. S. Naval Air Development Center

DP An Automatic A-C Generating System for Aircraft. *L. R. Oman*, Boeing Airplane Company

DP56-435 Parallel Operation of Aircraft A-C Generators: Reactive Load Division and Selective Protection. *H. A. Kuhle*, Jack and Heintz, Inc.

56-436 Frequency Modulation and Load-Division Instability in Parallel Alternator 400-Cycle Aircraft Electric Systems. *Henry Oman*, Boeing Airplane Company

12:15 p.m. Luncheon

Terrace Room, Baker Hotel

Presiding: E. B. Robertson

Speaker: Hon. D. A. Quarles, Secretary of the Air Force

2:00 p.m. General Session

Presiding: S. M. Sharp, vice-president, District 7

Address by: C. J. McCarthy, chairman, board of Chance-Vought Aircraft, Inc.

7:00 p.m. Power Systems

Presiding: J. B. Robuck

56-437 Automatic Load Frequency Control, Houston Lighting and Power Company. *W. C. Gierisch, D. E. Simmons*, Houston Lighting and Power Company

DP Reserve Capacity in Electrical Power Systems Requirements and Supplies. *Arnold Rich*, Federal Power Commission

Aircraft Technical Session—Transistor Applications

Presiding: T. H. McNary

DP Silicon Transistor Circuits for Aircraft Electrical Equipment. *C. R. Rutherford*, Temco Aircraft

DP Transistor Aircraft Interphone Amplifier Systems. *G. S. Rambie, Jr.*, Texas Instruments

DP Transistorized Thermocouple Temperature Indicating System. *G. H. Cole*, Minneapolis-Honeywell Regulator Company

55-822 A Transistorized Overvoltage Relay. *N. F. Schuh*, Westinghouse Electric Corporation. Re-presented for discussion

Tuesday, April 3

9:00 a.m. Power Generation

Presiding: L. E. Cook

DP Nuclear Power Plant Development. *R. W. Kinster*, Allis-Chalmers Company

Future AIEE Meetings

Paper and Pulp Conference
University of Florida, Gainesville, Fla.
March 8–9, 1956
(*Final date for submitting papers—closed*)

AIEE-ASME Fourth Annual Engineering Management Conference
Hotel Statler, St. Louis, Mo.
March 14–15, 1956
(*Final date for submitting papers—closed*)

AIEE, Illinois Institute of Technology American Power Conference
Sherman Hotel, Chicago, Ill.
March 21–23, 1956
(*Final date for submitting papers—closed*)

AIEE-ASME Nonlinear Controls Conference
Princeton University, Princeton, N. J.
March 26–28, 1956
(*Final date for submitting papers—closed*)

South West District Meeting
Baker Hotel, Dallas, Tex.
April 2–4, 1956
(*Final date for submitting papers—closed*)

AIEE-IRE-ISA Magnetic Amplifiers Conference
Syracuse Hotel, Syracuse, N. Y.
April 5–6, 1956
(*Final date for submitting papers—closed*)

Rubber and Plastics Conference
Mayflower Hotel, Akron, Ohio
April 9–10, 1956
(*Final date for submitting papers—closed*)

Great Lakes District Meeting
Fort Wayne, Ind.
April 16–18, 1956
(*Final date for submitting papers—closed*)

AIEE, ASME, ISA Recording and Controlling Instruments Conference
Bradford Hotel, Boston, Mass.
April 26–27, 1956
(*Final date for submitting papers—closed*)

AIEE-IRE Electronic Material and Component Symposium
Washington, D. C.
May 1–3, 1956
(*Final date for submitting papers—closed*)

North Eastern District Meeting
Rochester, N. Y.
May 2–4, 1956
(*Final date for submitting papers—closed*)

Summer and Pacific General Meeting
San Francisco, Calif.
June 25–29, 1956
(*Final date for *TP—Mar. 27, †CP Syn.—Apr. 10, CPMs—Apr. 20*)

AIEE-IRE-ISA Telemetering Conference
Ambassador Hotel, Los Angeles, Calif.
August 20–21, 1956
(*Final Date for *TP—May 20, †CP Syn.—June 5, CPMs—June 15*)

*TP—Transactions paper
†CP SYN.—Conference Synopsis
CP MS—Conference Manuscript
(The CP Syn. date is 10 days before the CP Ms date)

DP Progress in Nuclear Power Generation. *A. G. Maller*, General Electric Company

DP Recent Advances in Turbine and Generator Designs. *D: W. R. Morgan, Jr., J. C. Cunningham*, Westinghouse Electric Corporation

DP Trend and Development in Large Turbine Generators. *J. A. Zimmerman*, Allis-Chalmers Company

Transmission and Distribution

Presiding: John Hutchison

DP Load Characteristics and Their Effects on Distribution System Design. *H. E. Campbell*, General Electric Company

56-438 Connector Performance by Types. *O. A. Boyer*, Central Power & Light Company, and *Emerson Kerget*, Texas College of Arts and Industries

DP Fuse Protection of High Voltage Transformers. *Ray Larner*, Texas Electric Service Company

Aircraft Technical Session—Control and Protective Devices

Presiding: W. H. Crow

DP56-439 High-Phase Voltage Regulation on Aircraft Power Systems. *R. J. Loppla*, Jack and Heints, Inc., and *H. M. McConnell*, Carnegie Institute of Technology

56-440 Negative Sequence Voltage Detection on Aircraft A-C Systems. *R. D. Jesse, P. F. Bogust*, Westinghouse Electric Corporation

DP56-441 High Potential Testing of Aircraft Equipment Electrical Insulation. *L. B. Kilman, J. P. Dallas*, Hughes Aircraft

DP A New Solution to the Aircraft Boresighting Problem. *C. W. Clements*, Convair Division, General Dynamics Corporation

DP56-442 Recent Novel Positive Action Switch Designs. *H. F. Mason*, Mason Electric Corp.

55-436 Simplified Test Method for the D-Axis Transient Reactance and Time Constant. *C. F. Yohe*, Westinghouse Electric Corporation. (Re-presented for discussion)

Aircraft Technical Session—Electronic Applications

Presiding: C. W. Macune

DP Integrated Electronic Systems for Aircraft. *Robert Olson*, Collins Radio

DP Electronic Power Supplies in Aircraft. *H. T. Lowell*, Sorensen and Company

DP Cold Cathode Triodes in Timing Circuits. *H. D. Gulnac*, Los Alamos Scientific Laboratory

DP The Application of Wired Television To Augment and Extend Human Vision. *R. T. Silberman*, Kay Lab, Inc.

Chemical Session

Presiding: W. E. Silvus

DP Problems of the Utilities Furnishing Power to Chemical Plants. *M. T. Robbin*, Houston Lighting and Power Company

DP Chemical Plants Considerations in the Use of Purchased Power. *W. S. Miller*, Diamond Alkali Company, and *J. H. Valeit*, Shell Chemical Corporation

DP Expansion of Electrical Facilities in Chemical Plants. *H. N. Hickok*, General Electric Company

DP Over-all Aspects of Motor Control in Chemical Plants. *H. E. McConnell*, Consulting Engineer

Student Session

12:15 p.m. Luncheon—Honoring AIEE Board of Directors

Presiding: P. G. Wallace

2:00 p.m. Management Panel

Presiding: R. D. Ledbetter

Panel Discussion by leaders of Industry and Finance

Aircraft Technical Session—Environmental Design

Presiding: Harold Felix

DP Electronic Equipment Design Considerations Relative to Vibration and Shock. *B. L. Powell*, Chance Vought Aircraft

DP Design of Electronic Equipment to Resist Shock and Vibration. *K. C. Ford*, Convair Division, General Dynamics Corporation

DP56-443 Electronic Equipment Environmental Control in High Performance Aircraft. *H. R. Wesson*, Convair Division, General Dynamics Corporation

DP56-444 An Effective Method of Forced Air Cooling Airborne Electronic Equipment. *H. H. Thompson*, Melpar, Inc.

Chemical Session

Presiding: J. E. Parker

DP High Voltage D-C Testing of Cables and Cable Fault Locations. *B. J. Nankervis*, Dow Chemical Company

DP Corona in Metal-Clad Switchgear. *H. O. Bourque*, Ethyl Corporation

DP Problems and Limitations of Electrical Installations in Class I, Groups A and B, Hazardous Locations. *Dick Stout*, Crouse-Hinds Company

DP Motor Insulation Developments in the Chemical Industry—Now and Tomorrow. *J. T. Wilson*, Louis Allis Company

7:30 p.m. Dinner Dance—Entertainment

Presiding: George Smith

Wednesday, April 4

9:00 a.m. Distribution and Substation

Distribution Lightning Arrester Panel Debate. Presiding: B. M. Galleher, Texas Electric Service Company; Moderator: G. R. Coffman, Texas Power and Light Company; N. C. Spencer, Gulf States Utilities; D. P. Wooldridge, Dallas Power and Light Company; Ed Allen, General Electric Company; A. M. Opsahl, Westinghouse Electric Corporation; J. H. Willox, Joslyn Company; H. O. Stoelting, Line Material Company

DP Insulation Co-ordination as Affected by New Arrester Characteristics. *A. M. Opsahl*, Westinghouse Electric Corporation

Aircraft Technical Session—Power Supplies

Presiding: E. L. Clark

DP An Evaluation of Lightweight Storage Batteries. *Ward Carter*, Bell Aircraft Corporation

56-445 Recent Trends in Aircraft Ground Power Electrical Equipment. *H. S. Sachrist, M. Rosenblatt*, and *C. M. Bryant*, General Electric Company

DP56-446 Development of a Precisely Controlled Ground Power Unit. *H. A. Slingsby*, Beech Aircraft Corporation

DP Integration of D-C Power Supplies for Airborne Electronic Equipment. *J. M. Murphy, H. D. Stevens*, Convair Division, General Dynamics Corporation

DP56-447 Design and Development of New Silicon Rectifier D-C Power Supply. *H. B. James*, Westinghouse Electric Corporation

Aircraft Technical Session—Feedback Control

Presiding: A. R. Teasdale

DP Spurious Signals in Missile Autopilot Systems. *Ken Day*, Chance Vought Aircraft

DP Hydraulic Servomechanisms for Aircraft Stability Augmentation. *S. S. Asendorf, A. P. Rasmussen*, Westinghouse Electric Corporation

DP Analysis of Sample Data Servomechanisms by the Root Locus Method. *D. F. Sellers*, Chance Vought Aircraft

56-448 Airborne Analog Computer Plots Aircrafts Own Position on a Mercator Chart. *T. A. Westover*, Servo Corporation of America

56-449 Important Factors Influencing the Choice between a Synchro and a Potentiometer as an Angular Position Pickoff. *H. A. Dinter, Jr.*, Minneapolis-Honeywell Regulator Company

2:00 p.m. Switchgear

Presiding: O. A. Boyer

56-225 Vacuum Switches for Power Systems. *J. E. Jennings, H. C. Ross*, Jennings Radio Manufacturing Company, and *A. C. Schwager*, Schwager-Wood Corporation

DP New Braidless Side-Break Switches. *S. C. Killian, Robert Kleb*, Delta-Star Electric Company

Aircraft Technical Session—Reliability Testing

Presiding: R. L. Olson

DP Flight Safety Aspects of Electrical Design. *W. F. Punk*, Convair Division, General Dynamics Corporation

DP Testing Aircraft Electrical Equipment for Specification Compliance. *B. B. Shaffer*, Convair Division, General Dynamics Corporation

DP Production Testing A-C Power Systems after Aircraft Installation. *R. A. Klotz*, Douglas Aircraft Corporation

56-450 Analyzing Missile Electrical System Reliability. *B. J. Wilson*, Naval Research Laboratory

Communications and Supervisory Control

Presiding: Gibbs Dyer

DP A Portable VHF Radio System with Three Multiplex Channels for Emergency Communications. *C. F. Crandell, B. Bartel*

DP Remote Controlled Unattended Pump Stations Utilized by Great Lakes Pipe Line Company. *P. R. Madden*, Great Lakes Pipe Line Company, *A. P. Riehl*, Westinghouse Electric Corporation

DP Simplify Utility Radio Communications. *F. V. Long*, Texas Eastern Transmission Corporation

North Eastern District Meeting May 2—4 at Rochester, New York

AT 10:30 A.M. on May 2, the AIEE North Eastern District Meeting will open its headquarters at the Sheraton Hotel in Rochester, N. Y. The opening session will be a general meeting. Those attending will be welcomed to Rochester by the Hon. Peter Barry, mayor, and the delegates will be welcomed on behalf of the AIEE by AIEE President, M. D. Hooven.

Rochester, known as the "Flower City," will have its numerous parks and many home gardens in full blossom at this time. Of particular interest should be Highland Park where, later in the month, Rochester's Lilac Festival takes place.

A well-rounded technical program has been planned, as well as numerous inspection trips through some of Rochester's major industrial plants. The social program will be complete in every respect. The morning of May 3 will be devoted to the district student prize paper contest.

Technical Sessions

A total of 13 technical sessions are scheduled after the general session. They will cover such diversified subjects as instrumentation, insulators and insulation, electronics, communication, transformers, industrial con-

trol, transistors and semiconductors, and illumination.

Opening General Session

A. M. Beebee, president of the Rochester Gas and Electric Corporation, will deliver the principal address at the opening general session on Wednesday, May 2 in the hotel ballroom. His topic will be "Public versus Private Power—Which Is Right?" The mayor will welcome attending members to Rochester and M. D. Hooven will open the session.

Smörgasbord

The dinner planned for Wednesday evening will be a smörgasbord in the hotel ballroom; following this, arrangements have been made for members and their wives to attend the American Bowling Congress 1956 Championships at the Rochester Community War Memorial building. Bus transportation will be provided. Tickets costing $5.50 each will be available covering the smörgasbord, admission to the Bowling Championships, and transportation. For those who do not wish to attend the Bowling Championships, tickets will be available for the smörgasbord at $4.50 each.

Dinner-Dance

The outstanding social event of the meeting will be an informal dinner-dance to be held in the hotel ballroom on Thursday, May 3. A well-known local orchestra will furnish the music for dancing; dinner music will be supplied by students from the Eastman School of Music. A cocktail hour in the Victorian Room of the hotel will precede the dinner-dance.

Price of dinner-dance tickets (including cocktail hour) will be $6 per person.

Hotel Reservations

Rooms have been arranged for all members and guests at the Sheraton Hotel. All members should make their reservations directly with the hotel. Hotel reservation cards will be included in the regular mailing from headquarters.

Prices are as follows:

Single with bath	$ 6.85–$11.85
Double with bath	10.35– 13.35
Twin-bed with bath	12.85– 15.85
Suites (one to four persons)	20.85– 47.55

Registration

Registration facilities will be open at 8 a.m. on Wednesday, May 2. The desk will be staffed from 8 a.m. to 5 p.m. Wednesday and Thursday, and from 8 a.m. until noon on Friday. Tickets to all events will be found here as well as copies of all papers, and information about the meeting and the city of Rochester.

Ladies Events

Ladies who attend as guests will have a varied and interesting schedule. A daily morning coffee hour will be held Wednesday, Thursday, and Friday mornings in the Sagamore Room of the hotel until 10:30 a.m. On Wednesday afternoon they will visit the Eastman House, considered the world's greatest photographic museum. (See information on the Eastman House under inspection trips.)

RUSSELL STATION, newest of the steam generation plants of the Rochester Gas and Electric Corporation, will be visited by members on one of the inspection trips scheduled for the AIEE North Eastern District Meeting.

On Thursday there will be a luncheon and bridge party at the Monroe Golf Club. Tickets for this luncheon will be $2.50 each. Transportation to and from the club will be provided in private cars by the local ladies committee.

The ladies are invited to take part in the smörgasbord on Wednesday evening and to attend the American Bowling Congress 1956 Championships with their husbands. They are also invited to attend the cocktail hour and dinner-dance on Thursday evening.

Inspection Trips

Four inspection trips have been arranged which offer something of interest to all members. Tickets will be available at the registration desk for each of these trips. These tickets should be procured as early as possible so plans can be completed for transportation.

Russell Station, Rochester Gas and Electric Corporation (*Wednesday afternoon, May 2*). Russell Station incorporates many recent engineering advances in high-pressure power-plant design. The plant will ultimately produce 230,000 kw of electrical power. The first two generation units installed are hydrogen cooled units rated at 40,000 and 50,000 kw. The turbines driving these units operate at 1,250 and 1,450 pounds per square inch gauge, 950 and 1,000 F, respectively. Pulverized coal is used as fuel. This plant is modern in all of its features and the second unit has a net plant heat rate of 9,625 Btu/kwhr. It is designed to blend into the lake-front residential area in which it is located.

The George Eastman House of Photography (*Thursday morning, May 3*). The home of George Eastman, built in 1905, is open free as his memorial. The old master paintings he collected are on the walls; the concert organ is played Sundays. Twenty-five spacious rooms are filled with a unique exhibition of the growth of photography from the earliest day to the present time. Animated displays show how photography works, and how it is used. At this exhibit you will see how photography serves mankind.

Lapp Insulator Company (*Thursday afternoon, May 3*). The LeRoy, N. Y. plant of the Lapp Insulator Company is one of the largest and most modern insulator plants in the United States. The plant is unusual because of the large variety of pieces that are constantly in production. They manufacture not only a conventional line of insulators, but have emphasized the production of line and station posts for transmission line and substation use. They also produce a wide variety of special porcelain ranging in size from the very small to some of the largest plastic process bushing porcelains that have ever been produced.

In addition, the LeRoy plant's new high-voltage laboratory, containing a $2^1/_2$ million-volt impulse generator and 1,050,000-volt, 60-cycle transformer set, is the newest of the high-voltage laboratories in the United States. The John Lapp High-Voltage Insulator Museum is part of the laboratory.

Kodak Park Works of Eastman Kodak Company (*Friday morning, May 4*). This city

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

within a city covers about 570 acres and employs approximately 20,000 people. Its interior production areas are kept spotlessly clean. Many of them are air-conditioned and much of the work is done in dark rooms since most photo products are light sensitive. More than 2,000 different film items, 300 different kinds of paper, 220 kinds of photographic chemicals, and 3,500 synthetic chemicals for research purposes are manufactured here. Seventeen tons of silver are used each week in manufacturing its sensitized photographic goods. About one-third of this production is for amateur use. The plant has its own power plant where it produces all its steam and electric power. Its refrigeration plant produces sufficient refrigeration to supply all the homes in New York City. It uses 22-million gallons of water each day and has its own railroad and fire department. It has a dial telephone system of 5,200 telephones which services its 116 major manufacturing buildings. Its well-known photographic research laboratory employs more than 600 people.

Student Activities

On Friday morning, May 4, the Student District Prize Paper Contest will be held and awards distributed. This special activity is to take place from 9:30 a.m. until noon.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Committees

C. G. Plomasen, general chairman; J. A. Glenger, vice-chairman and secretary; J. D. Hershey, advisory; H. A. Brown, chairman, Rochester Section; E. M. Morecock, meetings and papers; R. H. Rankin, registration and hotel reservations; C. E. Tuites, student meeting; R. A. Whitford, finance; Mrs. R. A. Whitford, women's arrangements; Francis Drake, publicity; G. F. Gleason, inspection trips and transportation; J. T. Johnson, treasurer and budget; R. W. McCarty, dinner dance; J. A. Scott, smörgasbord and ABC bowling party; Frank Starr, meeting room arrangements.

AIEE Board of Directors Meeting Held in New York City

THE BOARD OF DIRECTORS met on Thursday, February 2, 1956, at the Statler Hotel in New York, during the Winter General Meeting. Of the 27 members of the Board, 26 were present. A brief summary of some of the major actions taken is given here. More complete discussions of these and other problems before the Board will appear in future issues of *Electrical Engineering*.

Resolutions of appreciation for the work of the Winter General Meeting Committee were voted. Expressions of sympathy were dispatched to the family and colleagues of Hector Martinez D'meza, chairman of the Mexico Section, who died December 25, 1955.

Membership and Finances

Additions to the membership were approved as follows: 9 Fellows, 282 Members, 738 Associate Members, 93 Student Affiliates, and 3,598 Students. Biographical sketches of the newly elected Fellows of the Institute will appear in subsequent issues of *Electrical Engineering*.

Approval was given for the addition to the Code of Practice of the Board of Examiners permitting recognition (as part of the acceptable experience record of applicants for Associate Member or Member) of such items as: chairmanship of an Institute (National) Committee or a Section; or, in the case of a graduate of a curriculum in engineering or science not approved by the Board of Directors, to consider such accomplishments as promotion to a position of responsibility, publication of technical papers, inventions, professional engineering license, or advanced academic degrees.

The Treasurer reported a balance in the General Fund of the Institute, as of December 31, 1955, of $363,748.62 as compared with $84,489.07 on the same date in the previous year.

The Chairman of the Finance Committee reported that dues collected in the first eight months of fiscal 1955–1956, May through December, account for 97.5 per cent of the budgeted figure of $700,000. Expenditures are currently running slightly under the budget. A favorable balance at the end of the fiscal year is anticipated.

A reciprocal arrangement for the waiver of entrance fees between AIEE and the Institution of Electrical Engineers (Great Britain) was approved for implementation through Bylaw amendment. Other similar proposals were referred to the Finance Committee for study and report.

Section allotments will henceforth be issued by a single payment in October. Membership cards will be sent to all members with the first dues bill in May. The validation of the card, with a record of the dues payment, will be left to the member.

Constitution and Bylaw Changes

Amendments to the Constitution and Bylaws were voted as follows:

1. To delete Bylaw 34, thus permitting the Institute to sponsor or engage in expositions and exhibits in connection with its general meetings.

2. To amend Sections 2 and 3 of the Bylaws to permit the Board of Examiners to admit a Student member to Associate Member (or Student Affiliate to Affiliate) upon a receipt of a favorable reference from the Branch Counselor.

3. To recommend to the membership amending the Constitution and subsequently to amend the Bylaws to define the official Section Delegate to the Conference of Section Delegates as the "incoming chairman, chairman-elect, or newly installed chairman of the Section, or an alternate designated by the Section."

4. To amend Bylaw 123 to eliminate detailed specifications relative to the issuing and contents of the *Yearbook*.

Future Meetings

Policies with respect to the scheduling of district meetings (*Electrical Engineering*, September 1955, page 851) were relaxed, so that one, instead of three, weeks will be approved as the minimum interval between such meetings. Also, the objection to district meetings in the same year as a general meeting held in the District, will now be limited to summer general meetings.

New York was approved as the location of the Winter General Meeting in 1961, 1962, and 1963 with the further provision that the first week in February is to be the preferred time. A Constitutional amendment adjusting the latest date of the Nominating Committee meeting was contemplated.

Invitations were received for the summer and fall general meetings for all years through 1964. The Board was highly gratified and appreciative of these invitations. They were recorded without objection. It was decided, however, to limit definite commitments to five years in the future.

Approval was given to the following District 2 Meetings: 1958, Washington; 1959, Baltimore; 1960, Pittsburgh.

The establishment of Overseas Chapters was favorably considered and referred to the Committee on Constitution and Bylaws for formulation and further recommendations.

Student Branches

The Committee on Student Branches recommended, and the Board of Directors approved, the establishment of a Student Branch at the United States Naval Postgraduate School, Monterey, Calif.

Affiliate Student Branches were approved at the following four institutions: California State Polytechnic College, San Luis Obispo, Calif.; Bradford Durfee Technical Institute, Fall River, Mass.; New Bedford Institute of Textiles and Technology, New Bedford, Mass.; Seattle University, Seattle, Wash.

Proposals for Bylaw changes were received by the Board of Directors and referred to the Committee on Constitution and Bylaws. These changes would in effect: permit the appointment of other than a Counselor as Chairman of the (District) Committee on Student Activities (Bylaw 38); raise maximum tenure as a Student member from five to seven years (Bylaw 58); require the

chairman of a joint Branch to be a member of AIEE (Bylaw 65); and set a minimum number of AIEE Student members for the establishment of a Student Branch or a Joint Student Branch.

Technical Committees and Prizes

A petition was received for the establishment of a sixth technical Division of the Institute to be known as the Instrumentation Division. This new Division would represent an expansion of the present Committee on Instruments and Measurements. Action will be taken at the next meeting of the Board.

A proposal from the Committee on Prize Awards to explore the establishment of additional medals and awards along divisional lines was favorably received by the Board.

A request for an extention of time to May 1, 1956, for reporting on a study of the New Engineering Societies Center Building project was granted to the Special Task Committee created by the Five Societies in September 1956.

By formal action, the Board set Monday, June 25, 1956, as the date for the 1956 Annual Meeting. This will be the first day of the 1956 Summer General Meeting in San Francisco. The next meeting of the Board of Directors will be held on Tuesday April 3, 1956, in Dallas, Tex., during the South West District 7 Meeting.

Conference on Nonlinear Control Systems Scheduled for March 26–28

THE AIEE and the American Society of Mechanical Engineers (ASME) Conference on Nonlinear Control Systems will be held at the Frick Auditorium of Princeton University, Princeton, N. J., March 26–28. The conference is sponsored by the Feedback Control Systems Committee of the AIEE and by the Instruments and Regulators Division of the ASME.

Registration

The Registration Desk will be located in the lobby of the Frick Auditorium and will open at 8:30 a.m. All members and guests must register.

The conference fee covers the full conference, regardless of length of stays. The fees are as follows: $3 for members, $5 for nonmembers, and no charge for women guests. Preprints of all papers will be available in package form at the time of registration at reduced cost.

Papers by Mail

Single papers are available by mail from the AIEE and ASME headquarters. AIEE papers can be ordered from the American Institute of Electrical Engineers, 29 West 39th St., New York 18, N. Y. ASME papers can be obtained from the American Society of Mechanical Engineers Order Department, 29 West 39th Street, New York 18, N. Y.

Tentative Technical Conference on Nonlinear Control Systems

Monday, March 26

8:00 a.m. Authors' Breakfast, Princeton Inn

9:00 a.m. Registration, Frick Auditorium

10:00 a.m. Technical Session I, Frick Auditorium

Chairman: W. I. Caldwell, Taylor Instrument Co.

Vice Chairman: W. D. Archibald, Energy Control Co.

Nonlinear Phenomena. *C. A. Ludeke*, University of Cincinnati

Effects of Nonlinearities in Multi-Loop Lead Angle Prediction Systems. *A. A. Clark, H. J. Pixley*, General Electric Company

A Resume of the Development and Literature of Nonlinear Control Theory. *T. J. Higgins*, University of Wisconsin

1:00 p.m. Luncheon, Princeton Center

2:30 p.m. Technical Session II, Frick Auditorium

Chairman: A. R. Aikman, Schlumberger Instrument Company

Vice Chairman: William E. Karg, Public Service Electric and Gas Company

Electro-Hydraulic Servomechanism with an Ultra-High Frequency Response. *D. P. Eatman, C. K. Taft, R. L. Schuman*, Case Institute of Technology

Nonlinear Analogue Study of a High-Pressure Pneumatic Servomechanism. *J. L. Shearer*, Massachusetts Institute of Technology

A Dual-Mode Damper Stabilized Servo. *J. Jurrik*, Clevite-Brush Development Co.; *J. F. Kaiser, J. E. Ward*, Massachusetts Institute of Technology

Experiments with Optimalising Controls Applied to Rapid Control of Fluid Pressure with High Amplitude Noise Signal. *George Varu*, Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics

Representation of Nonlinear Functions of Two Input Variables on Analogue Equipment. *D. A. Elliott*, Curtiss-Wright Corporation

Tuesday, March 27

8:00 a.m. Authors' Breakfast, Princeton Inn

8:30 a.m. Registration, Frick Auditorium

9:30 a.m. Technical Session III, Frick Auditorium

Chairman: Ralph Kochenburger, University of Connecticut

Vice Chairman: W. H. Surber, Jr., Princeton University

Basic Methods for Nonlinear Control System Analysis. *T. M. Stout*, Schlumberger Instrument Company

56-455 Describing Functions Representing the Effect of Inertia, Backlash, and Coulomb Friction on Stability. *K. N. Satyadra*, Westinghouse Electric Corporation

How to Obtain Describing Functions for Nonlinear Feedback Systems. *K. Klotter*, Stanford University

56-456 Design of Contactor Servo Using Describing Function Theory. *S. K. Chao*, Atomic Instrument Company

12:45 p.m. Luncheon, Princeton Center

2:00 p.m. Technical Session IV, Frick Auditorium

Chairman: Harold Chestnut, General Electric Co.

Vice Chairman: J. M. Mosley, E. I. du Pont de Nemours Company (Inc.)

56-432 The Frequency Response of a Servomechanism Designed for Optimum Response. *J. C. West, P. N. Nikiforuk*, Manchester University, England

Design and Analogue Computer Analysis of an Optimum Third-Order Nonlinear Servomechanism. *H. G. Doll, T. M. Stout*, Schlumberger Instrument Company

Optimum Nonlinear Control. *Rufus Oldenburger*, Woodward Governor Company

56-455 A Phase Space Method for the Synthesis of Nonlinear Servomechanisms. *R. E. Kuba*, Wayne University; and *L. F. Kazda*, University of Michigan

6:15 p.m. Cocktail Party, Princeton Inn

Courtesy of Philadelphia Section AIEE-ASME

7:00 p.m. Banquet, Princeton Inn

Subject: **The Dynamics of Population**

Speaker: *Dr. F. W. Notestein*, Princeton University

Wednesday, March 28

8:00 a.m. Breakfast, Princeton Inn

8:30 a.m. Registration, Frick Auditorium

9:30 a.m. Technical Session V, Frick Auditorium

Chairman: E. F. Johnson, Princeton University

Vice Chairman: E. G. Holzmann, Shell Development

On the Analysis of Linear and Nonlinear Systems. *Marvin Shinbrot*, Ames Aeronautical Laboratory, National Advisory Committee for Aeronautics, Moffett Field, California

Physical and Mathematical Mechanisms of Instability in Nonlinear Automatic Control Systems. *R. E. Kalman*, Columbia University

Determination of the Characteristics of Multi-Input and Nonlinear Systems from Normal Operating Records. *T. P. Goodman*, MIT

Spectral Response of Control Systems Containing Zero-Memory Nonlinearity to Random Inputs. *Yashiaro Sawargi*, Kyoto University; and *Sitsu Takahashi*, Kyoto Technical College

12:45 p.m. Luncheon, Princeton Center

2:00 p.m. Technical Session VI, Frick Auditorium

Chairman: Mead Bradner, The Foxboro Company

Vice Chairman: W. E. Reser, Princeton University

Hunting Due to Lost Motion. *H. Poritsky*, General Electric Company

56-454 Comparison of Backlash and Hysteresis Effects in Autonomous Second Order Feedback Systems. *L. M. Vallese*, Polytechnic Institute of Brooklyn

Nonlinear Integral Compensation of a Velocity Lag Servomechanism with Backlash. *C. N. Shen*, Dartmouth College; *H. A. Miller, N. B. Nichols*, Raytheon Manufacturing Company

Disturbance Response Feedback for the Control of Nonlinear Systems. *J. A. Hrones*, Massachusetts Institute of Technology; *R. E. Murphy*, General Dynamics Corporation; and *J. B. Reswick*, MIT

Engineers Joint Council General Assembly Attracts Some 500 Engineers

THE SECOND ANNUAL general assembly of Engineers Joint Council (EJC), held January 26–27, in the Hotel Statler, New York, N. Y., was attended by approximately 500 engineers. The two-day program, presented to promote the dissemination of information about engineers and their profession included forums on the Reserve Forces Act 1955, utilization of balanced teams of engineers and engineering technicians, growth pattern of the engineer, and the Hoover Commission reports.

Opening Session

The first session on Thursday morning, January 26, was opened with a greeting by Col. L. F. Grant, past president, Engineers Council for Professional Development (ECPD). Dr. H. A. Meyerhoff, executive director, Scientific Manpower Commission, was chairman of this session on the Reserve Forces Act of 1955, which was cosponsored by the Conference on Scientific Manpower, including the Engineering Manpower Commission, Scientific Manpower Commission, National Research Council, and the National Science Foundation. The three speakers, bearing major responsibility for military and related manpower problems in the Government, presented an over-all picture regarding the regulations governing the selection of persons having critical skills for enlistment in units of the Ready Reserve of the Armed Forces on approval six-months' active-duty training program. They assured engineers in industry that the Government was concerned and would co-operate in maintaining the country's lead in developing scientists and engineers.

The realism of the reserve program, in the light of present conditions and future dangers, was emphasized in the talk by C. L. Burgess, Assistant Secretary of Defense for Manpower and Personnel. He pointed out that the program provides greater flexibility of choice for young people and a more equitable sharing of the military obligation, as well as a greater degree of predictability for industry. Maj. Gen. L. B. Hershey, Director of Selective Service System, said that regarding the selection of those for Ready Reserve, we should "add generosity to the rules when they apply to persons with technological knowledge." Brig. Gen. C. S. Dargusch, assistant director for manpower, Office of Defense Mobilization (ODM), discussed the responsibility of the ODM in connection with specialized personnel, such as engineers and scientists, "to give the United States and the free world the best possible chance of maintaining technological superiority"; however, that "such superiority is by no means guaranteed" unless "a major, imaginative, and sustained effort is made." He seconds the suggestion of Director Arthur Flemming, ODM, that American enterprise establish immediately a fund of not less than $1 million annually to provide for honors and awards to individuals who have distinguished themselves in studies or in contributions to science and engineering beneficial to the nation. Following the presentation, questions were asked the speakers to clarify various provisions included in the Government's program.

Luncheon

The luncheon speaker, F. H. Bowles, director of the College Entrance Examination Board, presented, under the title "Brainpower—Our Greatest Asset," a current picture of the relation of our nation's brainpower potential to estimated needs. He warned that "we are running short of brainpower," and presented the results of a study recently completed on undeveloped brainpower, which indicated that an increasing amount of effort will be needed to encourage the education of this ever diminishing potential group, but "so long as this is a question that is of equal concern to business, industry, and education, the prognosis, both for our youth and our nation, is favorable."

Engineering Manpower

The theme of the Thursday afternoon session was "Extending Engineering Manpower by Utilizing Balanced Teams of Engineers and Engineering Technicians." The training of the relatively new occupational group of engineering technicians and their place in industry were considered by representatives of the electrical, automotive, aircraft, construction, petroleum, and chemical industries. Dr. M. M. Boring, chairman, Engineering Manpower Commission (EMC), was chairman of the session.

Dr. E. A. Walker, dean, College of Engineering, Pennsylvania State University, spoke on "Preparation and Relative Capabilities of Engineers and Engineering Technicians," and described the two-year training program of engineering aids in comparison to the regular engineering course at Pennsylvania State University. Dr. L. E. Saline, manager, Headquarters Recruiting, General Electric (GE) Company, in his talk, "Recruitment, Training, and Placement of Technical Institute Graduates—A Centrally Controlled Program," said that GE has had a technician program since 1946, for supplying supporting members to technical teams; he outlined the three phases of the program, including recruitment, orientation, and placement. Dr. S. W. Hewald, engineering manager, Air Arm Division, Westinghouse Electric Corporation, discussed "Planning the Ideal Engineer-Engineering Technician Team in a New Engineering Department" describing the organization of one particular electronics department at Westinghouse in 1951 in which engineers and technicians work together; it described also the use of technicians for special services departments.

This was followed by a series of short presentations on the specific methods used to achieve an efficient engineer-engineering technician team in various industries. Leon DeMause, administrative engineer, Cadillac Motor Division, General Motors Corporation, presented an organization chart of divisions at General Motors, showing the special areas for consolidation of engineering services in which technicians are used. J. C. Sanders, staff engineer, engineering department, Boeing Airplane Company, discussed the use of a semitechnical force at Boeing for drafting, computations, and data taking, as well as the drafting training program. Donald Rollins, vice-president in charge of engineering, American Bridge Division, United States Steel Corporation, described how the heavy construction industry uses engineering assistants for surveying, detail plan drawing, and many other assignments; that 62 per cent of those in the engineering department are technicians. R. F. Baldaste, administrative director, Whiting Laboratories, Standard Oil of Indiana, said that technicians are performing more and more jobs previously performed by engineers, and are used in some areas in all but supervisory work. Dr. John Volpe, commissioner of public works, Commonwealth of Massachusetts, said that approximately one third of the employees are semitechnical graduates, and that rotation of duties is important.

At the end of the program a discussion period permitted the presentation of individual problems, which included the possible advancement of technicians to managerial positions, the standardization of procedures and equipment as aids to technicians, and the shortage of engineering manpower because of compulsory retirement.

Growth Pattern of the Engineer

A highlight of the meeting was Friday morning's discussion of the growth pattern of the engineer. Panel moderator was S. D. Kirkpatrick, McGraw-Hill Book Company. The educator's viewpoint was discussed by Dean M. P. O'Brien, chairman, department of engineering, University of California, who said that from among the engineering graduates "industry obtains qualified managers and the graduates obtain positions which fit their interests and aptitudes," although "admission requirements and the curricula of engineering schools generally aim to prepare their students for development and design." He commented on the fact that an investigation of the productivity of England and the United States in 1949 showed our greater productivity to lie mainly in our greater number of technical school graduates in industry.

The employee's viewpoint was given by Robert Nelsen, General Electric Company, who said each engineer should chart his progress into three phases in professional development, namely: technical accomplishments, personal growth, and community affairs participation; he gave a number of criteria for evaluating progress.

The industrial aspects from the employer's viewpoint was presented by J. H. Taylor, director of industrial relations, Proctor and Gamble, who stated that some inhibitors to the growth of young engineers, over which an employer may have some control, are the assignment to noncreative nontechnical jobs, isolation from areas in which management concepts are evolved, and treatment as a member of an unidentified mass; he gave steps employers might take to alleviate conflicts.

Human problems in engineering from a broader viewpoint were discussed by Earl Brunner, management consultant of Rogers, Slade, and Hill, who enumerated five

MEETING HIGHLIGHTS

Jan.–Feb. 1956

Winter Meeting

Above: M. D. Hooven (center) president of the AIEE, greets Dr. R. E. Heartz (left), president, and L. A. Wright, general secretary, of the Engineering Institute of Canada. Below left: left to right are J. P. Neubauer, vice-president of the New York Section; R. M. Blough, chairman of the board of United States Steel Corporation, keynote speaker; M. D. Hooven; and A. J. Cooper, chairman of the General Committee of the Winter General Meeting. Below center: Members enjoying the Sunday afternoon tea. Below right: The registration room at the Statler.

phases on which professional status, as confirmed by others, depends: title, scientific reputation, social regards, material rewards, and cultural sensitivity; he said that direct action to acquire status defeats itself.

Questions asked of the speakers at the close of the session brought out the facts that an engineering education is of great value in the development of a scientific viewpoint, that from two to four years are needed to determine whether a young engineer is more valuable in management or in design, and that industry should feel obligated to supply schools with instructors on a part-time basis.

Luncheon

At the luncheon on Friday, Dr. S. C. Hollister, dean, School of Engineering, Cornell University, and a member of the Hoover Commission, spoke on the "Major Findings of the Hoover Commission." He said that competition between Government agencies and private enterprise is made increasingly unfair because of the higher income taxes now imposed and "there appears no present indication that agencies are trying to level off in size," which has resulted in "inadequate accounting, lack of inventory, wide confusion, hidden subsidies, conflict of objectives, and the attendant duplication and waste." In conclusion he said that "none of the achievements recommended by the commission will come about if the citizens of the country sit on the sidelines. We have the biggest and most expensive Government in the world. We are on trial to see whether we can make it effective without its becoming our master."

Hoover Commission Reports

The Friday afternoon session was devoted to a presentation of "The Hoover Commission Reports—A Review of the Engineering Aspects." Dr. Mervin Kelley, president, Bell Telephone Laboratories, discussed the "Research and Development" aspects.

Adm. Ben Morcell, board chairman, Jones and Laughlin Steel Company, and chairman of the Task Force on Water Resources and Power of the Hoover Commission, discussed the water resources and power aspect. The commission had been authorized to enter the field of policy, and to determine whether a function was being performed efficiently, or even to recommend the elimination of a function. Four areas were covered and reported on by the Task Force on Water Resources and Power, namely: power generation and distribution, reclamation and water supply, flood control, and improvements to water navigation.

Dinner

At the annual dinner on Friday evening, Dean Thorndike Saville, retiring president of Engineers Joint Council (EJC), addressed the general assembly. W. L. Cisler, president of the Detroit Edison Company, guest speaker, gave an appraisal of the social significance of atomic power in a talk on "A World Look at Usefulness of Nuclear Power." He expressed confidence that atomic energy ultimately would bring about industrialization and better living for people in underdeveloped areas, and said that "throughout the world, human progress and the utilization of energy go hand in hand." However, he emphasized that a number of limiting factors in atomic energy development must be considered.

Industrial Control Conference To Be Held in Boston, Mass.

The AIEE conference on New Developments in Instrumentation for Industrial Control will be held in Boston, Mass., April 26–27.

The introduction to the technical program will be made by R. J. Jeffries of the Schlumberger Instrument Company.

The tentative technical program is as follows:

Session I

Information Display and Recording

Chairman: P. A. Borden (Ret.), Bristol Company

The Human Bottleneck in Data Systems. *B. S. Benson*, Benson-Lehner Corporation

The Dynamics of Electronic Self-Balancing Systems. *G. R. Jacob*, Brown Instruments Division, Minneapolis-Honeywell Regulator Company

A New Type Recorder Mechanism. *R. C. Langford*, Weston Electrical Instrument Corporation

A New Concept in Display and Recording. *J. A. Peterson*, Radiation, Inc.

A Novel Character Display Storage Tube. *H. M. Smith*, Hughes Aircraft Company

Session II

Automatic Data Handling Systems

Chairman: A. J. Hornfeck, Bailey Meter Company

Modern Scanning, Monitoring, Display, and Circuitry Techniques in Plant Data Systems. (*To Be Announced*) Panellit, Inc.

Analogue-to-Digital Conversion; Telemetering Needs and Techniques for Modern Production and Research. *C. P. Spaulding*, G. M. Giannini and Company

Transducer-Transmitters for Modern Data Systems. *J. V. Werme* and *W. F. Newbold*, Brown Instruments Division, Minneapolis-Honeywell Regulator Company

A New System for Analogue Acquisition and Digital Processing of Data. *William Knox*, Consolidated Electrodynamics Corporation

New Developments in Radio Telemetry Systems. *G. S. Shaw*, Radiation, Inc.

Session III

Advanced Instrumentation Systems in Industry

Chairman: W. H. Howe, Foxboro Company

Advanced Data System in the Atomic Industry. *F. Hanmula* and *W. H. Howe*, Foxboro Company

Advanced Data System in the Aircraft Industry. *W. P. Hamilton*, Leeds and Northrup Company

Advanced Data System in the Chemical Industry. *T. M. Vick-Roy*, E. I. du Pont de Nemours Company (Inc.)

Advanced Data System in the Power Industry. *G. M. Keyser*, The Hydro-Electric Power Commission of Canada

New System for Wind Recording and Controlling. *R. B. Colt*, Bendix Aviation Corporation

Session IV

Computer-Controlled Systems for Industry

Chairman: J. W. Percy, U. S. Steel Corporation

Operations Research and Computer Control. *L. G. Peck*, Arthur D. Little Company

Optimized Utility Operations. (*To Be Announced*) General Electric Company

Suggestions for and Development of Self-Determining Computer-Control Systems. *H. Ziebolz*, Askania Regulator Company

Solid State Devices Versus Tubes for Computer-Controlled Systems. *N. B. Nichols*, Raytheon Manufacturing Company

American Power Conference Will Be Held in Chicago in March

The American Power Conference, sponsored by the Illinois Institute of Technology in co-operation with 13 universities and 10 local and national engineering societies, will be held March 21–23, at the Sherman Hotel, in Chicago.

The purpose of the conference is to provide a forum for the exchange of information in the fields of power generation, transmission, distribution, and utilization.

There will be 24 technical sessions, 4 of which will be devoted to water technology. Luncheons will be held on each day of the conference with featured speakers and an All Engineers Dinner will be held Thursday evening at which J. T. Rettaliata, president of the Illinois Institute of Technology will be the principal speaker.

All interested persons are cordially invited to attend. Registration information may be obtained from Dr. E. R. Whitehead, Secretary, American Power Conference, Illinois Institute of Technology, Chicago 16, Ill.

The tentative technical program of the American Power Conference follows:

Wednesday, March 21

9:00 a.m. Registration

10:00 a.m. Opening Meeting

Chairman: J. H. Ward, Commonwealth Edison Company; Co-Chairman: D. H. Loughridge, Northwestern University

Invocation

Power Makes the Difference. *R. S. Stevenson*, Allis-Chalmers Manufacturing Company

(To be announced) *Hon. C. A. Davis*, Under Secretary of the Interior, Washington, D. C.

12:15 p.m. American Power Conference Luncheon

Sponsored by the American Society of Mechanical Engineers (ASME)

Chairman: (To be announced)

Co-Chairman: J. N. Wognum, ASME, and Acme Steel Company

The Electric Industry in This Year of Decision. Harllee Branch, Jr., Edison Electric Institute, and Georgia Power Company

2:00 p.m. Central Station Steam Generators

Chairman: H. L. Solberg, Purdue University; Co-Chairman: N. A. Hall, New York University

High Capacity Two-Furnace Boilers. *E. M. Powell*, Combustion Engineering, Inc.

Supercharged Boiler Design Development and Application. *E. L. Duncan* and *R. F. Zoschak*, Foster Wheeler Corporation

Hydroelectric Power Development

Chairman: B. G. Elliott, University of Wisconsin; Co-Chairman: R. L. Young, Northwestern University

Underground Hydroelectric Stations in Brazil. *A. J. Ackerman*, Consulting Engineer

The Wisconsin River—The Hardest Working River in the Nation. *M. W. Kyler*, Wisconsin Valley Improvement Company

Gas Turbine Power Plants

Chairman: J. I. Yellott, Stanford Research Institute; Co-Chairman: B. G. A. Skrotzky, *Power* Magazine

(To be announced)

Thermodynamic Performance and Design of Combined Steam-Gas Turbine Power Plants. *J. W. Moss*, General Electric Company

Gas Turbines for Peak Load Generation on a Large Utility System. *W. D. Marsh* and *C. M. Wright*, General Electric Company

Electrical Distribution

Sponsored by Power Group, Chicago Section, AIEE

Chairman: Harold Kirk, AIEE, Public Service Division of Commonwealth Edison Company; Co-Chairman: H. L. Hoeppner, Pioneer Service and Engineering Company

Importance of Distribution Systems. *C. M. Lytle*, Kansas City Power and Light Company

Economic Loading of Distribution Transformers. *C. F. Mitchell*, Commonwealth Edison Company

3:30 p.m. Steam Generators—Removal and Disposal of Slag and Fly Ash

Sponsored by Power Group, Chicago Section, ASME

Chairman: N. L. Markesich, ASME, and Commonwealth Edison Company; Co-Chairman: J. T. Anderson, Michigan State College

Chemical Treatment for Fireside Deposit Prevention in Coal Fired Furnace. *Harris Thompson*, National Aluminate Corporation

Fly Ash and Slag—Materials of Value. *R. B. Preston*, Commonwealth Edison Company

Electric Power Stations

Chairman: W. A. Lewis, Illinois Institute of Technology; Co-Chairman: F. V. Smith, Sargent and Lundy, Engineers

Economics of Replacement of Generator Capacity. *L. B. LaVecomte*, Sargent and Lundy, Engineers

Major Auxiliary Drive Motors in Steam Electric Power Plants. *A. E. Baardmon*, General Electric Company

7:30 p.m. Nuclear Energy Forum

Chairman: R. D. Maxson, Commonwealth Edison Company; Co-Chairman: L. C. McCabe, Resources Research, Inc.

An interesting program is being arranged to help keep engineers and executives in the power industry up to date on the latest developments in the field of nuclear energy for power production. A panel of four prominent speakers will participate, after which questions from the floor will be answered. The fields to be covered are: role of Government in nuclear power development, role of industry in nuclear power development, research in nuclear power, and problems of insurance of nuclear power plants.

Speakers to be announced.

Thursday, March 22

9:00 a.m. Electrical Industrial Systems

Sponsored by Industrial Group, Chicago Section, AIEE. Chairman: J. N. Banky, AIEE, and Allis-Chalmers Manufacturing Company. Co-Chairman: M. S. Helm, University of Illinois

Problems in Cable Selection. *E. E. McElveen*, Okonite Company

Corrosion of Piping and Conduits in Industrial Plants. *R. M. Wainwright* and *D. P. Price*, University of Illinois

Utilization of 400 Cycles, 1,000 Volts in Industrial Power Plants. *V. C. Cuttler*, General Motors Corporation

Motor Starting Problems on Industrial Distribution Systems. *H. W. Cory*, Allis-Chalmers Manufacturing Company

12:15 p.m. American Power Conference Luncheon

Sponsored by the AIEE

Chairman: M. D. Hooven, President, AIEE, Public Service Electric and Gas Company; Co-Chairman: R. B. Gear, AIEE, and Commonwealth Edison Company

Speaker: H. D. Vogel, Tennessee Valley Authority

2:00 p.m. Symposium on Secondary Voltages

Chairman: A. D. Caskey, Commonwealth Edison Company; Co-Chairman: L. M. Haupt, Agricultural and Mechanical College of Texas

Economics of 240/480 Volts as Residential Utilization Voltage. *D. K. Blake*, General Electric Company

Higher Secondary Voltages—A Solution to Future Residential Distribution. *R. F. Lawrence*, Westinghouse Electric Corporation

Discussions. Engineers from Baltimore Gas and Electric Company, Cleveland Electric Illuminating Company, Detroit Edison Company, Philadelphia Electric Company, and other utility companies.

Air Pollution Session

Chairman: G. N. Hawley, Southern California Edison Company; Co-Chairman: *M. A. Elliott*, Illinois Institute of Technology

Significance of Sulfur Dioxide as an Air Contaminant. *L. C. McCabe*, Resources Research, Inc.

Implications of Current Air Pollution Legislation. *F. S. Mallette*, American Society of Mechanical Engineers

Air Pollution Research. *W. L. Faith*, Air Pollution Foundation

6:45 p.m. All Engineers Dinner

Entertainment: University of Wisconsin Glee Club, Warren Wooldrige, director.

Speaker: J. T. Rettaliata, Illinois Institute of Technology

Friday, March 23

9:00 a.m. Industrial Power Plants

Chairman: M. P. Cleghorn, Iowa State College. Co-Chairman: W. E. Ibele, University of Minnesota

Some Features of a Recently Constructed Pulp Mill Power Plant. *E. J. Martin*, The Procter and Gamble Company

Linden Generating Station—A Large Scale Exchange of Extraction Steam for Refinery Residual Fuel. *F. P. Fairchild*, Public Service Electric and Gas Company

Experience with Centralized Control of a Three-Unit Boiler Installation. *G. F. Hoff* and *L. C. Laird*, Corn Products Refining Company

9:00 a.m. Electronic Applications

Sponsored by Electronics Group, Chicago Section, AIEE.

Chairman: H. L. Messerschmidt, AIEE, Western Electric Company; Co-Chairman: A. W. Kramer, Power Engineering

Fault Location Experience Using Current Ratio Method. *M. J. Lantz*, Bonneville Power Administration

The Cryotron, a Superconductive Electronic Component. *D. A. Buck*, Lincoln Laboratory

10:30 a.m. Transmission Systems

Chairman: E. T. B. Gross, Illinois Institute of Technology; Co-Chairman: E. L. Nicolson, General Electric Company

The Case for Extra-High Transmission Voltage on American Power Systems. *H. W. Collins*, The Detroit Edison Company

Recent Radio Interference Investigations. *G. E. Adams*, General Electric Company

12:15 p.m. American Power Conference Luncheon

Sponsored by Western Society of Engineers

Chairman: A. P. Boysen, American Bridge Company; Co-Chairman: F. D. Carvin, Illinois Institute of Technology

Speaker: John Jirgal, Second Hoover Commission, and Public Utility Financial Consultant

2:00 p.m. Computers and Network Analyzers

Chairman: E. C. Starr, Bonneville Power Administration; Co-Chairman: E. B. Eggers, Illinois Institute of Technology

Application of Economic Dispatch Computers to Power Systems. *H. W. Colburn*, West Penn Power Company; *R. T. Byerly* and *R. B. Squires*, Westinghouse Electric Corporation

A New Concept in Automatic Dispatching. *R. E. Franck*, General Electric Company

Application of Digital Computers in Power System Analysis. *P. L. Dandeno*, The Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada

New Operating Methods Speed Up Network Computer. *W. E. Enns*, Portland General Electric Company; and *R. C. Rumpack*, Electronic Contractors, Inc.

Nuclear Power

Chairman: J. C. Boyce, Illinois Institute of Technology; Co-Chairman: Stuart McLain, Argonne National Laboratory

Special Engineering Features in Design of the Experimental Boiling Water Reactor Plant. *A. Kolstad*, Sargent and Lundy, Engineers

Design Review of 10,000-Kw Boiling Water Nuclear Power Plant. *Howard Grantz*, General Electric Company

Second ECPD Engineering Training Booklet Published

The Industry Training Committee of the Detroit Area, Engineers' Council for Professional Development (ECPD) has published a booklet, the second in a series, entitled "Detroit Industry Engineering Training Program." This booklet, on orientation and training in industry of young graduate engineers during the first five years of their employment, is a continuation of the program started in Cincinnati and mentioned in the 22nd Annual Report (1953–54) of the Engineers' Council for Professional Development. The general purpose and objectives of this program were described in the first booklet of the series.

The participating societies of this program are the AIEE, the American Society of Civil Engineers, the American Institute of Chemical Engineers, the American Institute of Mining and Metallurgical Engineers, the Engineering Institute of Canada, the American Society of Mechanical Engineers, the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners.

Correspondence regarding the booklets or the program should be addressed to: Industry Training Committee, Engineering Society of Detroit, 100 Farnsworth Avenue, Detroit 2, Mich.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until March 30. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before March 30.

55-284 **Equivalence Theorems, Analysis, and Synthesis of Single-Phase Induction Motors with Multiple Nonquadrature Windings.** *S. S. L. Chang*

55-322 **Sources of High Power Factor in Dry-Type Transformers.** *G. A. Monito, L. B. Rademacher*

55-524 **Field Tests of Response of Excitation System for a Synchronous Condenser.** *A. N. Eliasen*

56-137 **Operation of Large Synchronous Generators in the Dynamic Stability Region with a Modern Amplidyne Voltage Regulator. Part I. Recommendations for Setting the Underexcited Reactive-Ampere Limit.** *R. A. Phillips, A. S. Rubenstein*

56-138 **Operation of Large Synchronous Generators in the Dynamic Stability Region with a Modern Amplidyne Voltage Regulator. Part II. Operating Tests and Analytical Studies.** *K. R. McClymont, P. L. Dandeno, R. A. Phillips*

56-170 **Higher Voltage Primary Distribution.** *A. J. Pansini*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 38, N. Y.

Magnetic Amplifiers Conference To Be Held in Syracuse, N. Y.

A Special Technical Conference and Exhibit on Magnetic Amplifiers, cosponsored by the AIEE Committee on Magnetic Amplifiers, the Institute of Radio Engineers (IRE) Professional Group on Industrial Electronics, and the Instrument Society of America (ISA), Central New York Section, will be held in Syracuse, N. Y., at the Syracuse Hotel on April 5 and 6. Technical sessions, a manufacturers' exhibit of magnetic amplifiers, components, and associated products, and a banquet on Thursday evening, April 5, are planned. Dr. O. G. Haywood, Director of Sylvania Electric Waltham Laboratories, Waltham, Mass. will be the banquet speaker.

The first technical session will be tutorial in nature and will consist of four papers by invited speakers who are well-known authorities in their respective fields.

The remaining three technical sessions will each consist of papers chosen from those submitted to the Technical Program Committee and will cover the subjects of materials, components, theory, and application.

The committees are as follows: Steering Committee, C. F. Spitzer, H. W. Lord, and A. B. Haines; Technical Program, P. L. Schmidt; Publications, David Feldman; Hotel Arrangements, John Becker; Registration, August Haedecke; Finance, J. W. Munnis; Publicity, F. J. Lingel; Coordination, C. F. Spitzer; Exhibits, Samuel Seeley.

The registration fee for the conference will be $3 and the cost of the banquet Thursday evening will be $5 per plate. Papers presented at the conference will be published subsequent to the conference in the Report of the Special Technical Conference and will be available at $4 each if ordered in advance, or at the conference. Exhibit space can be obtained at a cost of $2.50 per square foot. The usual booth size is 6 feet by 8 feet or 6 feet by 10 feet. This charge includes the booth, background curtains, a table, and chairs. Manufacturers desiring exhibit space are invited to contact S. Seeley, Department of Electrical Engineering, Syracuse University, Syracuse, N. Y. For other information write C. F. Spitzer, Building 3, General Electric Company, Electronics Park, Syracuse, N. Y.

The tentative technical program for the conference is as follows:

Session I

Paul Schmidt, Chairman; John E. Hart, Co-chairman

1. **A General Introduction to the Theory of Magnetic Amplifiers,** *W. C. Johnson*, Princeton University

2. **Recent Advances in the Theory of Magnetic Amplifiers,** *R. Barker*, Yale University

3. **Fundamentals of the Magnetization Processes,** *Charles Boss*, General Electric Company

4. **Present Methods of Core Evaluation, Matching, and Grading,** *R. W. Roberts*, Westinghouse Electric Corporation

Session II

August Haedecke, Chairman; W. E. Good, Co-chairman

1. **Core and Lamination Shape Factors in Magnetic-Amplifier Design,** *H. R. Brownell*, Magnetic Metals Company

2. **An Analysis of Magnetic Amplifiers in Push-Pull,** *L. A. Finzi* and *D. L. Critchlow*, Carnegie Institute of Technology

3. **Design Criteria for a Practical Flux-Reset Core Tester,** *J. R. Jaquet*, Westinghouse Electric Corporation

4. **A Sensitive Single-Turn Hysteresis Loop Tester,** *F. Bernstein, T. H. Bonn*, and *R. D. Torrey*, Sperry-Rand

5. **Correlation of Hysteresis Loops, Core Tests, and Magnetic-Amplifier Control Characteristics,** *W. J. Muldoon*, General Electric Company

Session III

Fred Lingel, Chairman; John Becker, Co-chairman

1. **Magnetic Amplifier Controlled Regulated Rectifiers,** *H. L. Goldstein* and *R. J. Lowell*, Bell Telephone Laboratories, Inc.

2. **Regulated Power Supplies with Silicon Junction Reference,** *D. Szegio*, Westinghouse Electric Corporation

3. **A 75-Kw Magnetic Amplifier,** *K. Epstein*, University of Rochester

4. **A High Temperature Regulated D-C Power Supply for Aircraft,** *R. G. Engman, R. E. King*, Westinghouse Electric Corporation

5. **Half Cycle Response Magnetic Amplifiers with Transistor Driver for Voltage Regulation,** *E. Pihenakis*, Bell Telephone Laboratories, Inc.

Session IV

Dr. Samuel Seeley, Chairman; Norman Balabanian, Co-chairman

1. **A Magnetic Voltage Reference,** *E. W. Maninofsl R. O. McCary*, General Electric Company

2. **Capacitively Coupled Magnetic Amplifiers,** *H. W. Collins*, Westinghouse Electric Corporation

3. **60-Cycle Self-Balancing Magnetic Servo Amplifier,** *W. A. Geyger*, Naval Ordnance Laboratory

4. **Magnetic Arbitrary Wave-Form Generator,** *C. B. Howe*, Naval Research Laboratory

5. **Magnetic Amplifiers for the Control of Servo Motors,** *A. R. Perrins*, Yale University

Electronic Components Symposium, Washington, D. C.

A comprehensive review of accomplishments in the electronic components field and a survey of future trends will highlight the 1956 Electronic Components Symposium which is scheduled to be held in Washington, D. C., May 1–3. This is the seventh in a series of annual technical meetings devoted to electronic components.

The theme of the three-day meeting is to be "Components—Accomplishments and Trends." Top flight industry and Government engineers and scientists will deliver technical papers covering present and future developments of a variety of electronic components. Arrangements for the 1956 Symposium are under the direction of A. W. Rogers, U. S. Army Signal Corps. The technical program is being developed under the supervision of P. S. Darnell, Bell Telephone Laboratories, Inc.

Sponsored by the AIEE, The Institute of Radio Engineers, the Radio-Electronics-Television Manufacturers Association, and the West Coast Electronic Manufacturers Association with the active participation of the Department of Defense and the National Bureau of Standards, the three-day program will be divided into seven sessions, including an evening session devoted to electron tubes and solid-state devices.

The opening session on Tuesday, May 1, will be of a general nature and will include addresses by leading industry and Government authorities from the United States, England, and Canada.

Approximately six speakers will be heard during each of the following seven sessions: Opening, Progress with Materials, Theory and Operating Principles, Instrumentation and Measurements, Electron Tubes and Solid-State Devices (evening), and two sessions on Passive Components.

Official Nominees Announced for 1956 AIEE National Election

M. S. Coover, head of the Electrical Engineering Department, Iowa State University, Ames, Iowa, was nominated for the AIEE presidency by the AIEE Nominating Committee at its meeting held in New York, N. Y., January 30, 1956. Others nominated for election to Institute offices for terms beginning August 1, 1956 are:

For Vice-Presidents:

D. E. Garr, assistant division engineer, General Engineering Laboratory, General Electric Company, Schenectady, N. Y. (*District 1*)

L. F. Stone, engineer, Apparatus Sales Office, General Electric Company, Newark, N. J. (*District 3*)

J. H. Foote, president, Commonwealth Services, Inc., Jackson, Mich. (*District 5*)

N. F. Rode, professor of electrical engineering, Texas Agricultural and Mechanical College, College Station, Tex. (*District 7*)

M. M. Ewell, manager, Engineering and Service Department, Westinghouse Electric Corporation, Portland, Ore. (*District 9*)

H. H. Kerr, vice-president in charge of operations, Toledo Edison Company, Toledo, Ohio. (*District 11*)

For Directors:

W. R. Brownlee, Southern Services, Inc., Birmingham, Ala.

A. A. Johnson, engineering manager, Switchgear Division, Westinghouse Electric Corporation, Pittsburgh, Pa.

L. M. Robertson, chief electrical engineer, Public Service Company of Colorado, Denver, Colo.

Renominated for Treasurer:

W. J. Barrett, New Jersey Bell Telephone, Newark, N. J.

The Nominating Committee, in accordance with the Constitution and Bylaws, consists of 20 members: 1 selected by the executive committee of each of the 10 geographical Districts, 1 selected by each of the 5 technical divisions, and 5 selected by the Board of Directors from its own membership.

The Constitution and Bylaws of the Institute require publication in *Electrical Engineering* of the nominations made by the Nominating Committee. Provision is made for independent nominations as indicated in the following excerpts from the Constitution and Bylaws:

Constitution: Article VI, Section 33. Independent nominations may be made by a petition of twenty-five (25) or more corporate members sent to the Secretary when and as provided in the Bylaws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

Bylaws: Section 28. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 33 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with Article VI of the Constitution and sent by the secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

A list of members of the Nominating Committee appeared in the January issue of *Electrical Engineering*, p. 85.

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographic sketches are scheduled for inclusion in the "AIEE Personalities" columns of the April issue.

Textile Industry Electrical Application Conference March 1–2

The 1956 Conference on the Electrical Application for the Textile Industry, scheduled for March 1 and 2, will be held in the auditorium of the Hightower Textile Building in Atlanta, Ga.

The Conference committee is as follows: S. A. Bobe, Westinghouse Electric Corporation; H. S. Colbath, Bibb Manufacturing Company; Swaffield Cowan, Factory Insurance Association; H. A. Dickert, A. French, Georgia Institute of Technology; R. B. Flowers, General Electric Company; R. S. Gardner, American Institute of Electrical Engineers; R. H. Hanson, Cutler-Hammer, Inc.; C. H. Hudson, General Electric Company; Dan McConnell, Cone Mills; J. T. Meador, Southern Electric Service Company, Inc.; V. P. Sepavich, Chairman, AIEE Textile Subcommittee; J. W. Ward, Avondale Mills.

The tentative technical program for the conference is as follows:

Thursday, March 1

9:00 a.m. Registration at Hightower Textile Building

10:00 a.m. Morning Session

Presiding: Victor Sepavich, Chairman, AIEE Textile Subcommittee

Welcoming Address. *B. R. VanLeer*, Georgia Institute of Technology

Report on "Proposed Recommended Practices for Electrical Installation on Textile Machinery." *R. H. Clark*, Warner and Swasey Company

What Management Expects of Its General Engineer. *Herman Granberry*, West Point Manufacturing Company

Field Testing and Improvement of Dynamic Balance. *Peter Davey*, Vibroscope Company

12:00 noon Discussion

12:30 p.m. Recess for Lunch

2:30 p.m. Afternoon Session

Presiding: H. S. Colbath, Bibb Manufacturing Company

What Is New in Lighting. *E. A. Linsley*, General Electric Company

Electrical Testing Instruments. *R. S. White*, Universal Winding Company

4:15 p.m. Open Discussion

6:30 p.m. Social Hour, Atlanta Athletic Club

7:30 p.m. Banquet

(Speaker to be announced)

Friday, March 2

9:30 a.m. Morning Session

Presiding: Swaffield Cowan, Factory Insurance Association

The Fundamentals of Electronics. *F. O. Nottingham, Jr.*, Georgia Institute of Technology

Why We Need Recommended Practices for Electric Installations on Textile Machinery. *Swaffield Cowan*, Factory Insurance Association

11:00 a.m. Panel Discussion

What Is Your Problem? Moderator, *J. D. McConnell*, Cone Mills Corporation

A selected panel of engineers will be appointed to answer questions and discuss practical problems concerning textile plant electrical installations and operations. Visitors are urged to bring their questions and participate in this important part of the program.

World Power Conference Scheduled for June 17–23

The Fifth World Power Conference will be held in Vienna, Austria, from the 17th to 23rd of June. The theme selected for the Conference is "World Energy Resources in the Light of Recent Technical and Economic Developments."

The headquarters of the Conference is at the Konzerthaus, Vienna III., Lothringerstrasse 20. The offices of the Conference will open on Friday, June 15, 1956, at 8 a. m.

The membership fee for participants is 1,200 Austrian schillings. There are included in this price a set of the papers including the general reports and the *Conference Journal*. Members will be admitted to all the technical sessions and to the social events held.

Persons applying for membership of the Fifth World Power Conference must fill in a special form. It is requested that these forms, duly filled in be submitted to the National Committee of the World Power Conference or representative of the participant's own country, together with the fee of 1,200 Austrian schillings for participants and 500 Austrian schillings for persons accompanying participants. The respective National Committees and World Power Conference representatives are requested to forward all applications and fees in bulk to the Austrian National Committee.

Arrangements have been made for a number of events to take place during the week of the Conference. These include the opening meeting, a reception given by the Austrian Government for the foreign visitors, special gala performances at the state theaters, and a typically Viennese evening entertainment at the Schönbrunn Palace.

There will also be a number of tours to the various hydroelectric plants, thermal plants, and industrial establishments in Austria, and to hydroelectric plants situated in the frontier areas of Germany, Italy, and Yugoslavia. The itinerary has been chosen to provide for visits to places of historical interest and to give participants the opportunity of seeing some of Austria's magnificent scenery.

During the Conference week there will be whole-day and half-day excursions to the power plants located in Vienna and its neighborhood.

Whole-day and half-day trips through the immediate and more distant surroundings of Vienna, as well as conducted sightseeing tours of the city and visits to other places of interest, have been specially arranged for the ladies.

Arrangements have been made for a number of tours to power plants and other interesting installations in Austria, which will take place after the conclusion of the Conference. These tours also include visits to places of historical and cultural interest and the routes will lead through some of the most beautiful parts of Austria. In order to emphasize the significance of the Central European Power Distribution System, some of the tours will include visit to power plants located in the frontier areas of Germany, Italy, and Yugoslavia.

The papers submitted to the Fifth World Power Conference will not be read at the technical sessions. This is to keep all the available time free for discussions. The General Reporter will give only a short introduction to the topic for discussion.

Preprints of the papers submitted to the Conference and preprints of the general reports can only be forwarded to those participants whose applications reach the Austrian National Committee by April 15, 1956, at the very latest in the case of those participants living outside Europe, and April 30, in the case of those in European countries.

The papers and general reports will be published in full in the complete bound "Transactions of the Fifth World Power Conference," which will also contain summaries of the discussions, the Chronicle of the Conference, a list of participants, and an index.

Judging by the number of papers received by November 15, 1955, it is thought possible that about 300 papers will be dealt with under five divisions.

For more detailed information on this Conference write to the United States National Committee World Power Conference, 29 West 39th Street, New York 18, N. Y.

American Automation Research Expenditures to Increase

Annual expenditures by American industry and Government for scientific research and development can be expected to increase at least 50 per cent during the coming decade.

This belief was expressed by Dr. H. A. Leedy, director of Armour Research Foundation of Illinois Institute of Technology, Chicago, in a year-end statement.

Dr. Leedy cited a recent Federal Government forecast placing the country's gross national product at $540 billion in 1965. He stated that research expenditures currently amount to approximately $4 billion—1.1 per cent of the gross national product and if applied to the value of goods and services the United States is expected to produce in 1956, a total research volume of about $6 billion is indicated as being "on the conservative side."

He pointed out that for many years research and development expenditures have represented a steadily increasing percentage of the gross national product, and that research appropriations have risen from 0.1 per cent of the gross national product in 1920 to 1.1 per cent in 1955.

"A continuation of this trend," he added, "will increase research investments by many millions each year."

Dr. Leedy cited two major reasons for the steadily increasing industry interest in research: (1) growing realization that research "pays off handsomely" in sales and profits and (2) necessity to increase man-hour output because of a population that is rising faster than the labor force.

He referred to U. S. Department of Commerce figures which showed that the nation's population has increased more than 13 per cent in the last 7 years, whereas the total labor force has grown only 6.3 per cent in the same period, and a similar trend can be expected through the next decade or two.

Research will be given added impetus as the result of recent developments in science, particularly in the atomic energy, electronic, aeronautical, and automation fields.

Concerning the effect of automation on employment, Dr. Leedy believes automation will be a boon to mankind, and pointed out that it is coming at a time when the total population is increasing faster than the number of people available for productive work and, therefore, will result in a minimum of dislocations in business and industry. He feels, too, that automation will act as a deterrent to inflation—which danger is always present in an expanding economy—by increasing efficiency in the volume production of goods and services.

Howard Coonley Medal Awarded to H. S. Osborne

Dr. H. S. Osborne, retired chief engineer, American Telephone and Telegraph Company, received the Howard Coonley Medal for ". . . great service in advancing the national economy through voluntary standards." He was cited specifically for his work as president of the International Electrotechnical Commission. In his acceptance address, Dr. Osborne stressed the need for the early development of standards both nationally and internationally. He recommended that in new fields of work, international standards should be taken up at the same time as national standards.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Division

Committee on Relays (Frank von Roeschlaub, *Chairman;* W. K. Sonnemann, *Vice-Chairman;* G. W. McKenna, *Secretary*). The subcommittees and project committees have been actively working on several projects of interest to relay engineers. Among these is a bibliography of relay literature, definitions

of relay performance terms and revisions to existing relay terminology, a brochure on the principles of transmission line relaying, and surveys of the usage of the newer types of generator protective relays and the general principles and practices of relaying in this country.

A project committee is studying the protection of pilot wires used in protective relaying in collaboration with the Pacific Coast Subcommittee of the Relay Committee. Another group has started an extensive review of motor protection. A report on a survey of test methods will be published shortly.

The Relay Committee is maintaining an active liaison with other AIEE groups with which it has mutual interests.

Industry Division

Committee on Mining and Metal Industry (R. B. Moore, *Chairman;* F. R. Hugus, *Vice-Chairman*). The Metal Industries Subcommittee has been devoting attention toward "Power Systems for the Steel Industry" and "Automatic Control Systems in the Steel Industry." As a result, a technical session on power systems is scheduled for the 1956 Summer and Pacific General Meeting. Also, for the Summer and Pacific General Meeting this year a session is being scheduled on automatic control systems.

The Eastern Mining Subcommittee is reviewing a report of the Conversion Substation Committee on the subject of d-c equipment grounding practices. Correlation of the report with underground mining requirements is intended.

Science and Electronics Division

The Solid-State Devices Committee (J. P. Jordan, *Chairman;* S. J. Angello, *Vice-Chairman;* C. F. Spitzer, *Secretary*). This committee was organized to give additional attention to new developments and necessary standardizations of electronic components and devices in the semiconductor, magnetic, and dielectric fields. To carry out this work efficiently the committee has been divided into three subcommittees: one under Dr. Angello has been active for a number of years in the semiconductor field; the second under Mr. Spitzer is of more recent origin and is concerned with dielectric devices; the third is just being organized by Professor Welch in the field of magnetic devices. These are all joint subcommittees with the Institute of Radio Engineers to avoid duplication of effort.

In the standardization effort the Semiconductor Device Subcommittee has completed work on "Definitions of Semiconductor Terms," "Proposed Methods of Testing Transistors" (excluding Large-Signal Applications), "Proposed Letter Symbol-Standards for all Semiconductor Devices," and "Proposed Standards on Method of Test of Semiconductor Devices for Large-Signal Applications." Work is now under way on "Proposed Methods of Test for Junction Transistors for Large-Signal Applications," "Methods for Test for Bulk Semiconductors," "Photo Devices," "Diodes," and "Transistor Internal Parameters."

The Subcommittee on Dielectric Devices is presently engaged in assembling a list of definitions of terms for nonlinear capacitors. They are actively examining all the devices in the field to determine where the greatest need exists for their future standardization activities.

The Magnetic Devices Committee is, at this stage, just formulating its program.

All of these subcommittees in addition to their standardization activities are sponsoring programs at various meetings. It is expected that in the future this effort will be co-ordinated to provide a broad coverage of areas of interest in the solid state devices field by joint sponsorship of educational sessions at the major conventions. Papers on new devices and developments will continue to be sponsored individually.

The Committee and Subcommittee memberships are purposely being limited to those who can actively contribute to the technical effort. However, for those who desire to be kept advised of the work in progress but who cannot actively participate, associate memberships are being solicited. Such members would receive copies of all minutes and standards material in progress. Any persons wishing to be added to these lists should advise the subcommittee chairman involved.

AIEE PERSONALITIES

G. B. Entrekin (AM '46), chief product engineer of the International Resistance Company (IRC), Philadelphia, Pa., has been appointed plant manager of its fifth and newest manufacturing branch plant located in Burlington, Iowa. As chief product engineer he led a special research and development project on carbon composition resistors. Prior to joining the IRC organization seven years ago, he was product engineer for Western Electric Company in Kearney, New Jersey. A graduate of Drexel Institute of Technology, Philadelphia, Mr. Entrekin served five years with the U. S. Army Signal Corps. He is currently a member of the Armed Forces Communications Electronics Association, and is active on various Radio-Electronics-Television Manufacturers Association committees.

J. W. Percy (AM '52), physicist, of the Fundamental Research Laboratory, U. S. Steel Corporation, Kearny, N. J., was elected vice-president of the Instrument Society of America at the Society's 10th Annual Instrument-Automation Conference and Exhibit in Los Angeles, Calif., September 12–16. He will be responsible for the Society's Recommended Practices Division. Mr. Percy studied at the U. S. Military Academy and at Michigan State University, receiving degrees there in 1923, 1926, and 1929. He has worked at Olds Motor Works, United Alloy Steel Corporation, Central Alloy Steel Corporation, Republic Steel Corporation, and has been with U. S. Steel Corporation since 1935. For several years Mr. Percy has worked as a physicist and consultant to 27 plants on problems involving heating and rolling practice, furnace design, combustion and temperature measurement and control. He holds membership in the New Jersey and National Society of Professional Engineers and the Association of Iron and Steel Engineers. Mr. Percy was a member of the U. S. Army Reserve for 15 years prior to World War II and was on active duty in the Ordnance Department, Research and Development Division, from 1942 to 1945.

A. A. Timineri (AM '50), consulting engineer and technical adviser, has been appointed engineering and sales representative for the Wac Engineering Company of Dayton, Ohio. Mr. Timineri received his electrical engineering degree from the State University of Iowa and took his graduate studies at the University of Buffalo where he taught electronics for several years. He has been assigned the Pacific Coast States and will make his home in the Los Angeles area.

P. R. Sharadin (AM '53), in charge of industrial sales at the Odessa, Tex., office of the Minneapolis-Honeywell Regulator Company, has been assigned to the new position of regional application engineer for the southwestern region with headquarters in Dallas, Tex. Mr. Sharadin joined Minneapolis-Honeywell as an industrial controls service engineer in Dallas in 1951 and entered industrial sales work in the company's El Paso office the following year. He is a graduate of Union College.

M. C. Burns (AM '40), in charge of development and production design of digital-type equipment for Brush Electronics Company, Cleveland, Ohio, has been appointed chief engineer of El-Tronics, Inc. Mr. Burns, a native of Oakland, Calif., holds the degree of bachelor of science in electrical engineering from the University of California. Following his graduation, he took advanced studies in airline meteorology at the Boeing School of Aeronautics. He began his business career in 1941 as an instructor in navigation and meteorology for Pan American Airways (PAA) at Miami, Fla. Shortly after the attack on Pearl Harbor he was sent overseas as an instrumentation specialist for PAA Africa, a subsidiary of the airline. From 1942 to 1947, he held various engineering and administrative positions with PAA, advancing to section meteorologist. During that time he designed various meteorological instruments for production. In September 1947, Mr. Burns joined the Berkeley Scientific Corporation as a project engineer and the following year was promoted to chief engineer. In that position he was in complete charge of research, design, and development of a complete line of nuclear and electronic instrumentation. He left that company in 1952 to organize the Digital Instrument Company, Inc., Coral Gables, Fla. Two years later he sold the business to Brush Electronics Company, Cleveland, Ohio.

Mahmoud Riaz (AM '51), instructor, has been promoted to assistant professor of electrical engineering. He joined the Massachusetts Institute of Technology (MIT) staff in 1947. Dr. Riaz, an Egyptian citizen,

was born in Paris and holds degrees from the University of Paris, University of Cairo, Rensselaer Polytechnic Institute, and MIT.

A. E. Cooper (AM '50), engineer, has been named manager of research and advanced development in the Airborne Computer Laboratories of the International Business Machines Corporation (IBM). Mr. Cooper was formerly a development engineer in the defense development engineering laboratory. He became associated with IBM in 1950 as a technical engineer in the physics laboratory, and transferred to defense engineering in 1951. He was appointed a project engineer in the defense development engineering laboratory the following year. Mr. Cooper studied chemical engineering at the University of Cincinnati, and earned bachelor and master of science degrees in electrical engineering from Purdue University. He has also completed a course in instrumentation and control at Massachusetts Institute of Technology. Mr. Cooper is a member of the honorary societies, Eta Kappa Nu and Tau Beta Pi. He served as a first lieutenant in the U. S. Army Air Corps during World War II. He holds membership in the Institute of Radio Engineers.

E. J. Horelik, Jr. (AM '48), field supervisor of the Whitney Blake Company, New Haven, Conn., has been appointed assistant sales manager of the Electronics Division. This division manufactures connectors for electrical, electronic, and aircraft circuits. A graduate of Rensselaer Polytechnic Institute, he served as airborne radar officer with the U. S. Air Force for 2½ years. Before joining the Whitney Blake Company in 1950 he was a sales engineer in the wire and cable division of the United States Rubber Company.

N. J. Dam (AM '50) who for the past three years has been a facilities engineer for the General Electric Company (GE) at Utica, N. Y., has been named plant engineer for the General Electric Research Laboratory here. In his new position, Mr. Dam will supervise engineering for service facilities in the various Research Laboratory installations, as well as for the facilities themselves. He is a graduate of Washington State College, Pullman, Wash. He joined GE as a test engineer in 1949, and served as a technical advisor at Electronics Park, Syracuse, N. Y., before taking the position at Utica.

E. L. White (M '37, F '47), retired chief of the Safety and Special Radio Services Bureau, Federal Communications Commission (FCC), joined the firm of Microwave Services, Inc., New York, N. Y., as senior consultant. He has been with the FCC since 1927 and among his many accomplishments was vice-chairman and spokesman for the U. S. delegation to the Atlantic City Conference of the International Telecommunication Union in Geneva in 1948 and 1949. As Colonel in the U. S. Army Air Corps Reserve, he served in World Wars I and II, with overseas duty in the Pacific and China-Burma-India Theaters and with the military government in Germany. His communications knowledge and experience was of great value in active duty and is also applied in his reserve status. Prior to his FCC service, Col. White was in charge of maintenance and operation of the fixed radio network for the U. S. Signal Corps in Hawaii and developed plans and procedures for maintenance and operation of tactical radio equipment for the Signal Corps. Prior to this period he was with the staff of the Naval Research Laboratory on development of crystal controlled transmitters, particularly those involving frequency multiplication. Col. White has served on the Instruments and Measurements Committee of the AIEE, and is a Fellow of the Institute of Radio Engineers.

G. V. Boselli (AM '49), assistant chief engineer, Hyer Industries, Inc., has joined the Instrument Division, sales engineering department, of Thomas A. Edison, Inc. and will represent the division in a territory covering the New York metropolitan area, New Jersey, parts of Pennsylvania, Maryland, Delaware, Virginia, and the Carolinas. He holds an electrical engineering degree from Manhattan College.

R. E. Pratt (AM '54), associate engineer, has been appointed associate staff engineer in the electrical laboratory of International Business Machines Corporation (IBM), Endicott, N. Y. Mr. Pratt was employed by IBM in August 1951 as a design engineer in the Endicott Laboratory and in January 1954 was made associate engineer in the electrical laboratory, a position he has held until his recent appointment. He was graduated from St. Lawrence University, Canton, N. Y., in 1949 with a bachelor of science degree in mathematics and in 1951 from Rensselaer Polytechnic Institute, Troy, N. Y., with a bachelor of science degree in electrical engineering. Mr. Pratt has been an instructor in refresher mathematics in the IBM school. He is currently enrolled in the IBM sponsored Syracuse University graduate program at Endicott. He is a member of the Institute of Radio Engineers.

F. W. Grahame (AM '53) of the General Electric Company's capacitor department at Hudson Falls, N. Y., has been notified that the U. S. Patent Office has granted him his second patent. His invention covers a technique for hermetically sealing Tantalytic (Registered Trademark) capacitors in glass. This design permits the capacitors to operate for longer periods with less electrolyte leakage than was possible previously. Mr. Grahame's first patent, also on a glass seal, was granted jointly to him and A. F. Torrisi in 1953. A native of St. Paul, Minn., Mr. Grahame was graduated from the University of Minnesota in 1947 with a bachelor of science degree in electrical engineering. He joined the General Electric Company at Pittsfield, Mass., and was assigned to capacitor development work in the transformer and allied products laboratory. In September 1952, he was transferred to the engineering section of the Hudson Falls plant. He is a member of the Institute of Radio Engineers.

Albert Hansen, Jr. (AM '37, M '45), manager of advanced engineering for General Electric (GE) Company's instrument department, has been appointed manager of engineering for GE's rectifier department. Mr. Hansen joined GE in 1936 after graduating from Pratt Institute with a bachelor of science degree in industrial electrical engineering. After completing the test engineering program, he came to West Lynn, Mass., in 1937 as a technical engineer in the works laboratory. In 1940, he became aircraft instrument engineer and four years later was appointed assistant technical superintendent of aircraft instrument manufacturing. The following year he was named to the staff of the works engineering manager. In 1947, he became section engineer of the Instrument Engineering Division and, in 1951, supervisor of advanced engineering. Early this year he was advanced to manager of advanced engineering at the instrument department. Mr. Hansen has won GE's highest achievement honor, the Coffin Award, and holds several patents on various phases of instrument development. He has served on the AIEE Industrial Control Committee (1953–55), and on the Instruments and Measurements Committee (1955–56). He is a member of the American Society of Mechanical Engineers, Instrument Society of America, and the Association of Professional Engineers.

G. W. Baughman (M '45), vice-president in charge of the railway signal engineering department, Westinghouse Air Brake Company, Union Switch and Signal Division, Pittsburgh, Pa., has been appointed to the staff of the vice-president and general manager and will act on management matters in a staff capacity. Mr. Baughman joined the engineering department of the Union Switch and Signal Company in 1923. From then until 1944 he was engaged mainly in field and development work. In 1944, he was appointed assistant chief engineer in charge of electronics and, in 1945, was named chief engineer. He was made assistant vice-president in charge of railway signal engineering, in 1950, and a vice-president of the Westinghouse Air Brake Company in 1951 when the corporate structure of the Union Switch and Signal Company was changed to that of a division of the Westinghouse Air Brake Company. He has membership in a number of engineering societies, including the British Institute of Railway Signal Engineers. He has served on the AIEE Committee on Special Communication Applications (1949–51, 1953–57).

A. B. Tillett (AM '47), district manager at Roanoke, Va., for Rumsey Electric Company of Philadelphia, Pa., has been appointed assistant manager, substation T. & D. Department, for Rumsey, with headquarters at Philadelphia, Pa. He has been succeeded at Roanoke by **H. B. Edwards, Jr.** (AM '54), formerly located in the Richmond Office, Va. Mr. Edwards graduated from the University of Virginia Engineering School.

J. N. Montgomery (AM '49), engineer at E. I. du Pont de Nemours and Company, Belle, W. Va., was promoted to assistant superintendent in the engineering development group of the technical section. He obtained his bachelor's degree in electrical engineering from the Alabama Polytechnic Institute in 1948, and his master's degree in electrical engineering from the Georgia Institute of Technology in 1953. Prior to his graduate work, he served as lieutenant

in the Signal Corps where he aided in developments in the fields of microwaves and radio link communication. Since joining the Du Pont company in 1953, he has been engaged primarily in the development of industrial process controls.

D. W. Webb (AM '48), engineer in charge of sales of switchgear assemblies and unit substations for the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., was named manager of sales, switchgear assemblies and unit substations; and **Albert Ewy** (AM '43), engineer in charge of switchgear equipments, was appointed chief engineer of switchgear assemblies. Mr. Webb joined the company in 1948. He is an electrical engineering graduate of the University of Nebraska and a member of the National Electrical Manufacturers Association. He has served on the AIEE Committee on Substations (1954–56). Mr. Ewy joined the company in 1930 and has been with the switchgear department since 1936. He is an electrical engineering graduate of the University of Minnesota. **W. G. Lewis** (M '49), assistant manager of sales, and **F. T. Gifford** (M '50), assistant chief engineer of the switchgear department, were named as managers of sales, circuit breakers, and chief engineers, circuit breakers, respectively, for the Allis-Chalmers Company, Boston Works. Mr. Lewis served as assistant engineer in charge of circuit breaker sales and assistant to the general manager. He joined the company in 1926. He has served on the AIEE Committee on Switchgear (1951–52). Mr. Gifford joined the company in 1937 and was an assistant division engineer for a large outdoor circuit-breaker line until 1946, when he was appointed division engineer. In 1954 he was named engineer in charge of circuit breaker design.

I. F. Kinnard (AM '21, F '43), engineering manager, West Lynn Works, General Electric Company, Lynn, Mass., has been appointed manager of special projects and studies, where he will integrate long-range planning for the company's instrument department. Dr. Kinnard was born in Ontario, Canada, and graduated from Queen's University with a bachelor of science degree in engineering and physics. After World War I service in the Canadian Army, he studied mathematics and physics at the University of Glasgow. He then joined the General Electric Company. In 1953, he was awarded the Lamme Gold Medal by AIEE, one of the highest awards in the electrical industry. He has served on AIEE committees: Instruments and Measurements (1927–41, chairman 1939–47), Technical Program (1939–41), Board of Examiners (1946–50), and Research (1953–56). **M. A. Princi**, manager of the measurements laboratory of the company, was appointed manager of engineering succeeding I. F. Kinnard. Mr. Princi joined the company after graduation from Boston English High School. He graduated from Lowell Institute in 1931, and earned a bachelor of science degree in electrical engineering in 1935 at the University of Colorado; later he did graduate study at the Massachusetts Institute of Technology. All his professional experience has been in the instrument department of the company where he has held numerous engineering assignments including engineer in charge of the specialty instrument section, and manager of aircraft instrument engineering. He is a member of The American Society of Mechanical Engineers, Instrument Society of America, Engineering Societies of New England (past chairman), and Michigan Society of Professional Engineers. He is presently serving as chairman of ASA Committee C-85 covering Terminology for Automatic Controls. He was chairman of the Lynn Section of the AIEE during 1949 and served as co-chairman and chairman respectively, for the 1949 and 1955 AIEE Summer General Meetings in Swampscott, Mass.

J. B. Russell (AM '34, F '51), consultant, General Electric Company, Syracuse, N. Y., has been appointed manager of the engineering analysis Subsection of the company's electronics laboratory. In his new position, Dr. Russell will work on special and theoretical electronics engineering problems arising in various areas of the Electronics Division. Dr. Russell joined the laboratory in July, 1955, coming from Columbia University where he was head of the department of electrical engineering. He received his technical education at the Massachusetts Institute of Technology. He is a Fellow of the New York Academy of Sciences, a member of the Association for Computing Machinery, and the American Society for Engineering Education. He has served on following committees of the AIEE: Standards (1939–50), Communication (1941–49), Basic Sciences (1947–49), Instruments and Measurements (1948–49), Industrial Control (1948–49), Feedback Control Systems (1949–50), and Liaison Representative on Standards Committee (1951–54)

G. A. Cypher (AM '52), head of material development group and supervisor of materials applications, General Electric Company, Lynn, Mass., has been appointed insulating materials specialist for General Electric Company's chemical materials department in Schenectady, N. Y. Dr. Cypher participated in the introduction of the "motorette" and an accompanying test cycle, both now being used as the basis for the new AIEE test code for motor insulation. He is a native of Butler, Pa., and received a bachelor of arts degree from Washington and Jefferson College. After 3 years service in the U. S. Navy as an electronics maintenance and repair officer, he received a bachelor of science degree from Monmouth College. He earned a doctors degree in organic chemistry at Notre Dame University in 1950.

M. H. Pratt (M '34, F '53), chief engineer, Central Division, Niagara Mohawk Power Corporation, Syracuse, N. Y., has been elected a vice-president and chief engineer for the corporation. He will succeed **E. S. Bundy** (AM '14, F '33, Member for Life), who will continue as a director and a vice-president of the corporation, and also will serve as an engineering consultant. Mr. Bundy has served on the AIEE Committees: Electrical Machines (1931–38), Power Transmission and Distribution (1932–36). Mr. Pratt graduated from the College of Engineering at the University of Pennsylvania. He started as a cadet engineer with the then Syracuse Lighting Company, Inc., one of the predecessor companies of the Niagara Mohawk System. He was placed in charge of electrical engineering for the Syracuse District and was made division electrical engineer several years later. He is a Fellow of the Edison Electric Institute and the American Standards Association. He is a former president of the Syracuse chapter, American Society of Professional Engineers, and a member of the United States Power Squadron, Syracuse Technology Club, Sigma Xi, and Tau Beta Pi. He has served on the AIEE committee on Transformers (1947–56). **J. T. Kimball** (AM '18, Member for Life), vice-president of the corporation has retired. Mr. Kimball, known throughout the natural gas and electric industry, will be retained as a consulting engineer. He received an electrical engineering degree from the University of Wisconsin and accepted a position with the system at Buffalo, N. Y., becoming a director of the Buffalo company. Later he was elected a vice-president and director of two other system subsidiary companies and moved his headquarters to Syracuse. From then until to date he has been the system's chief rate engineer. He has served on the AIEE committee on Public Relations (1950–55).

D. K. McIlvaine (M '44), manager of research and development, Soreng Products, Chicago, Ill., has been appointed to the newly created post of director of research and development for the Acro Manufacturing Company, Columbus, Ohio. His duties will include the development of new product lines. Mr. McIlvaine graduated with a bachelor of science degree from Washington and Jefferson College. He did post graduate work at Carnegie Technical Institute. He has served as manager for the meter department and test laboratories of West Penn Power Company, development engineer for the Bell Telephone Laboratories and Western Electric Corporation, and vice-president and works manager of the Henry Valve Company. He is a member of the Institute of Radio Engineers and the American Society of Refrigerating Engineers.

P. C. Ford (AM '38, M '44), assistant manager of the Transformer Engineering Division, Wagner Electric Corporation, St. Louis, Mo., has been appointed chief engineer of the Electrical Division to succeed **C. P. Potter** (AM '19, F '29), who is retiring after more than 46 years with the organization. Mr. Ford received a bachelor of science degree from Purdue University in electrical engineering, and joined the corporation as a student engineer. He worked for some years in the distribution and power transformer engineering sections, and was appointed supervisor of the unit substation and dry-type transformer engineering section in 1950. Mr. Potter, who will remain temporarily with the corporation in a consulting capacity, also joined the company as a student engineer, following his graduation from the University of Illinois. He has been very active in the work of various engineering organizations and has served for 25 years in the various groups of the motor and generator section of the National Electrical Manufacturers Association. He has served on the AIEE committees on Electrical Rotating Machinery (1941–53) and Technical Program (1943–45).

R. C. Cheek (AM '42, M '47), assistant manager of Westinghouse Electric Corporation, Baltimore, Md., Electronics Division, has been named manager of the industrial electronics department. The department will be part of the Industrial Heating Division which has its headquarters in Meadville, Pa. He will be responsible for the engineering, manufacture, and sale of induction heating equipment, power line carrier equipment, and a variety of other industrial electronic devices. Mr. Cheek joined the Westinghouse student training course following his graduation from Georgia Institute of Technology. He has been a consultant on power systems problems and an assistant sales manager for the corporation. He has served on the AIEE committees on Carrier Current (1950–54) and Electronics (1954–56).

J. W. St. Andre (AM '43, M '48), electrical engineer, Continental Electrical Equipment Company, Cincinnati, Ohio, has been named chief electrical engineer at Kaiser Aluminum and Chemical Corporation's Newark, Ohio, rod, bar, wire and electrical conductor mill. Mr. St. Andre is a graduate of General Electric Engineering School, Lynn, Mass., and has a degree in electrical engineering. He was formerly Educational Chairman for the AIEE New York Section, and has served on the AIEE National Committee for Industrial Power Distribution.

OBITUARIES

Robert Harsh Hull (AM '15, M '35, F '50, Member for Life), engineer, died on November 25, 1955, after a long illness. Mr. Hull was a graduate of the University of Colorado. He worked for the Great Western Sugar Company for several years, and in 1920 joined the University of Colorado as an instructor in the electrical engineering department. He was special engineer for several Spokane engineering jobs, and in 1943 became Associate Professor of Electrical Engineering at the University of Utah. During World War II he worked as a traveling electrical engineer for the 9th Service Command at which time he was on leave from the University of Utah. Prof. Hull was a member of the American Society for Engineering Education, Tau Beta Pi, and Sigma Tau.

Hector Martinez D'meza (AM '15, M '35, F '50, Member for Life), Works Manager for Industria Electrica de Mexico, a Westinghouse licenser and president of the Mexico AIEE Section, died on December 25, 1955. He was born on November 27, 1905, and graduated from the School of Engineering of the University of Mexico in 1930. In past years Mr. Martinez had worked for the Mexican government in various capacities. He was a member of the Centro Nacional de Ingenieros, S.A., and the Asociacion de Ingenieros y Arquitectos in Mexico.

Greenleaf Whittier Pickard (AM '03, M '08, F '12, Member for Life), electrical engineer and inventor, born in 1877, grand nephew of poet John Greenleaf Whittier died January 8, 1956. He was educated at Harvard University and MIT. Dr. Pickard specialized in radio communication, receiving many United States and foreign patents for his inventions. One of the first to obtain successful transmission of speech by electrical waves, he invented the crystal detector, the radio compass, and the static eliminator. Dr. Pickard held engineering positions successively with American Telephone and Telegraph Company, Wireless Specialty Apparatus Company, and RCA Victor Company of Massachusetts. He was an independent consulting engineer 1938–1948, and director of research for American Jewels Corporation from 1942 to 1945. In 1945 he became cofounder and president of Pickard and Burns, Inc., consulting radio and electronic engineers, and had been chairman of the board there since 1952. He was a past president and Fellow of the Institute of Radio Engineers (IRE), receiving the IRE Medal of Honor in 1926. He was a Fellow of the Radio Club of America, and received their Armstrong Medal in 1941. Other society memberships included the American Association for the Advancement of Science, the American Academy of Arts and Sciences, and the American Meteorological Society. He was active in Amateur Radio during the last 40 years holding the call letters W1FUR.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of January 19, 1956, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Ambuk, W. J., electronic equipment development engineer, Eastman Kodak Co., Rochester, N. Y.
Andrews, L. M., electrical engineer, DPW, 6th Naval District, Charleston Naval Base, S. C.
Antoss, H. J., mechanical engineer, U. S. Navy Bureau of Yards & Docks, Washington, D. C.
Bannon, C. F., associate electrical engineer, light dept., City of Seattle, Wash.
Beach, P. E., partner, The R. B. Dana Co., New York, N. Y.
Bright, R. C., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Buck, D. T., president, Buck Engineering Co., Inc., Freehold, N. J.
Burns, M. J., chief electrical engineer, Beiswenger, Hoch & Associates, Akron, Ohio
Chapin, C., associate electrical engineer, water supply dept., City of Detroit, Mich.
Chesher, T. A., Jr., relayman, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Chiarito, E. A., assistant engineer, Baltimore Gas & Electric Co., Baltimore, Md.
Chinburg, C. H., assistant professor of electrical engineering, Colorado A & M College, Fort Collins, Colo.
Collins, W. C., chief electronics engineer, communications dept., County of Los Angeles, Calif.
Coppage, L. F., chief electrical engineer, Wigton-Abbott Corp., Newark, N. J.
Cruz, J. F., electrical engineer, Ilocos Norte Electric Co., Laoag, Philippines
De Koranyi, L., head, electrical dept., Lundy Mfg. Corp., Long Island City, N. Y.
Foster, C. E., division supervisor, Sandia Corp., Albuquerque, N. M.
Fuchs, A. M., senior engineer, Air Arm Div., Westinghouse Electric Corp., Baltimore, Md.
Gore, J. W., Jr., engineer, Baltimore Gas & Electric Co., Baltimore, Md.
Grant, C. G., manager, product planning small motor dept., General Electrical Co., Fort Wayne, Ind.
Hadley, E. J., engineer, Westinghouse Electric Corp., Baltimore, Md.
Haines, A. B., transmission apparatus engineer, Bell Telephone Laboratories, Whippany, N. J.
Hart, J. E., section head, U. S. Naval Research Laboratory, Washington, D. C.
Harvey, J. A., project engineer, Pennsylvania Electric Co., Johnstown, Pa.
Henderson, P. T., unit leader, Bell Aircraft Corp., Buffalo, N. Y.
Hinshaw, R. A., chief laboratory engineer, Line Material Co., Zanesville, Ohio
Hoeho, G. L., Jr., senior research electrical engineer Magnolia Petroleum Field Research Lab., Dallas, Tex.
Johnson, R. R., application engineer, General Electric Co., Chicago, Ill.
Keen, R. N., sales engineer, General Electric Co., San Francisco, Calif.
Landis, H. L., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Mackenzie, W. F. Jr., field test supervisor, Pennsylvania Power & Light Co., Hazleton, Pa.
Manero, J. L., central office engineer, Telefonos de Mexico, Mexico, D. F., Mexico
May, G. E., relay engineer, Metropolitan Edison Co., Reading, Pa.
McGinnis, J. J., relay specialist, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Mierow, A. C., system dispatcher, Central & South West Operating Commission, Abilene, Tex.
Moss, B. W., project representative, The Glenn L. Martin Co., Baltimore, Md.
Muldoon, W. J., engineer, General Electric Co., Utica, N. Y.
Nawn, B. D., assistant engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Norlin, J. W. A., manager, Central Electric Cooperative, Inc., Redmond, Ore.
Peterson, A. E., electrical engineer, Diamond Ordnance Fuse Laboratories, Washington, D. C.
Preston, O. R., Jr., district engineer, Arkansas-Missouri Power Co., Caruthersville, Mo.
Quarles, G. G., director, ordnance research lab., Pennsylvania State University, University Park, Pa.
Shealy, F. K., electrical supervisor, Westinghouse Electric Corp., Charlotte, N. C.
Sidebottom, J. K., design engineer, General Electric Co., West Lynn, Mass.
Siegel, C. M., associate professor of electrical engineering, University of Virginia, Charlottesville, Va.
Somers, J. W., electrical engineer, Pacific Gas & Electric Co., San Francisco, Calif.
Sonon, A. H., supervisory engineer, Gilbert Associates, Inc., Reading, Pa.
Stevenson, J. R., Jr., application engineer, General Electric Co., Atlanta, Ga.
Stone, B. L., associate engineer, International Business Machines Corp., Poughkeepsie, N. Y.
Tussey, T. F., electrical engineer, Loftus Engineering Corp., Pittsburgh, Pa.
Warburton, F. W., laboratory supervisor, New England Power Service Co., Worcester, Mass.
Watson, T. F., Jr., application engineer, Commonwealth Associates, Inc., Jackson, Mich.
Weiss, Gerald, research engineer, The W. L. Maxon Corp., New York, N. Y.
Whitted, H. E., Jr., dept. chief, test planning, Western Electric Co., Winston-Salem, N. C.
Youtz, R. N., chief system operator, Connecticut Valley Power Exchange, Hartford, Conn.

55 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before March 25, 1956, or April 25, 1956, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Clark, K. C., Hydro-Electric Power Comm. of Ontario, Toronto, Ont., Canada
Collier, R. E., Farnsworth Electronics Co., Fort Wayne, Indiana
Craig, G. F., Perkin-Elmer, Inc., Norwalk, Conn.
Crowder, J. E., Aluminum Co. of America, Alcoa, Tenn.
daRoza, F. G., Barlum Hotel, Detroit, Mich.
Herold, G. F., Harry F. Wilson, St. Louis, Mo.
Hogan, C. A., Westinghouse Elec. Corp., Boston, Mass.
Holloway, D. W., Luzerne Elec. & Gas Div., The United Gas Improvement Co., Kingston, Pa.
Keck, M. E., Westinghouse Elec. Corp., Cleveland, Ohio
Lett, R. P., Syracuse University, Syracuse, N. Y.
Lippincott, C. D., Bradley & Williams, Inc., Syracuse, N. Y.
Loughren, A. V., Hazeltine Corp., Little Neck, N. Y.
McCammon, G. A., Creole Petroleum Corp., Caracas Venezuela
Morris, F. A., Stromberg-Carlson Co., Rochester, N. Y.
Nimeroff, Bertram, Bureau of Ships, Navy Dept., Washington, D. C.
Norton, R. L., Powell Electrical Mfg. Co., Houston, Texas
Pardy, W. J., Northern Electric Co. Ltd., Lachine, P. Q., Canada
Perkins, C. W., Moloney Elec. Co., St. Louis, Mo.
Proescholdt, W. H., Quaker Oats Co., Chicago, Ill.
Saito, Y., Tokyo Institute of Technology, Tokyo, Japan
Sansted, V. L., 30 Church St., New York, N. Y.
Stachiewicz, B. R., Stromberg-Carlson Co., Rochester, N. Y.
Sykes, W. L., Miller Electric Mfg. Co., Inc., Appleton, Wisconsin
Van Bladel, J. J., Washington University, St. Louis, Mo.
Visanuvimol, V., Siam Cement Co. Ltd., Bangkok, Thailand
Wagner, E. A., New Orleans Public Service, Inc., New Orleans, La.
Whenman, A. R., General Electric Co., Boston, Mass.
Yun, Y. C., Korea Electric Power Co., Seoul, Korea

28 to grade of Member

OF CURRENT INTEREST

STROBEACON UNIT in new approach system at New York International Airport being inspected by (left to right): Robert M. Brown, Civil Aeronautics Administration; Capt. Ernest Cutrell, American Airlines; S. Christopher Peek, Sylvania Electric Products, Inc.; and Capt. John Gill, Eastern Air Lines.

EFAS Strobeacon Guides Pilots Landing with Limited Visibility

A STREAK OF LIGHT resembling tracer bullets traveling at the supersonic speed of 2,700 miles per hour was put into operation recently at New York International Airport (Idlewild), New York, N. Y., to guide planes in landing during periods of limited visibility.

Installation of the electronic flash approach system (EFAS) at Idlewild, which will supplement the centerline approach lighting system now in use, developed by engineers of Sylvania Electric Products Inc., is expected to reduce flight delays and cancellations, and lessen air traffic control problems. The new Strobeacon centerline approach system, EFAS, greatly broadens the all-weather applications of the Airport's existing lighting system.

It will result in a greater number of successful approaches; an "unsuccessful approach," in aviation parlance, occurs when the pilot comes in low for a landing but is forced by conditions of visibility to gain altitude again, circle the airport, and make another attempt to land. Successful first approaches will not only mean fewer delays for passengers, but the airlines will also benefit from the reduced delays and cancellations through the use of the Sylvania system.

According to Captain John Gill, chief pilot of Eastern Air Lines, the sequenced flashing in the Sylvania system quickly focuses the pilot's attention and instantly identifies the lights as an approach lane. The directional feature is of great aid to the pilot, he explained, because it eliminates the momentary problem of orientation that usually exists when a pilot first breaks out beneath an overcast. The time necessary for the pilot to become oriented depends upon the visibility under the overcast, and normally extends until the plane's position is fixed with relation to the known position of identified lights and landmarks, he said.

Because the approach to the instrument landing strip at Idlewild is over water, the Port of New York Authority, which administers airports in the New York metropolitan area, has installed platforms for mounting the approach lighting system on a pier which extends 2,500 feet into Jamaica Bay. The flashing Strobeacon units begin at the extreme outward end of the pier some 3,000 feet from the runway. They continue to within 1,100 feet of the runway. The system is activated by the controller in the airport control tower during low-visibility weather or at the radioed request of the incoming pilot.

This airport lighting improvement in the New York area has been welcomed by pilots flying into Idlewild, and other metropolitan area airports could well follow New York's example in providing increased safety for the air traveling public.

The Idlewild installation is particularly significant because it will be used by pilots from all over the world. Last year 24 foreign and domestic airlines operating from Idlewild transported almost 4-million passengers on flights across the United States and overseas.

It is expected that the C.A.A., in its constant emphasis on safety and schedule reliability, would consider adopting the Strobeacon system at many other airports throughout the country. Accurate navigation aids make it relatively easy for a pilot to come through the thickest weather down to the last half mile. After that, however, he must see where he is going. This EFAS now is the visual aid on the field which matches the electronic aids in the air.

Optics Considerations

Twenty flashing units are placed at a distance of 1,000 feet from the end of the runway to 3,000 feet, at 100-foot intervals. The re-

XENON-FILLED CONDENSER LAMP, heart of the new approach lighting system installed at Idlewild, produces beam of over 30-million candle power.

flectors give a 25-degree beam which intercepts the electronic glide path at a point 1,600 feet in front of the particular lamp. The flashes are synchronized so that the unit at the 3,000-mark will flash first and then each successive unit until all 20 have flashed. This entire cycle is repeated twice per second. The flashes, therefore, create the effect of a continuously moving ball of fire, shooting toward the runway. Since each flash is of extreme brightness (30 million candlepower), it easily penetrates diffusing water particles or snow in which any other light source would be lost. Inasmuch as the flash is of short duration (approximately 1/5,000 of a second), it does not disturb the pilot's dark adaptation. However, it is long enough to be easily recognized.

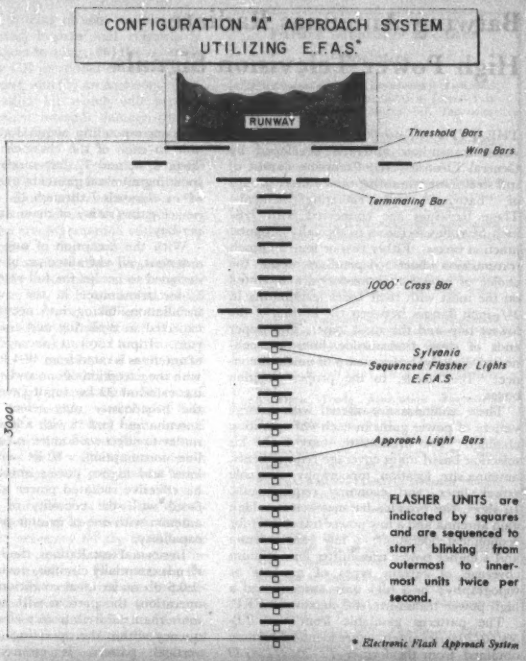
There are several advantages in the Sylvania flashing Strobeacon which include recognition of this source as an approach system. In other words, there is no possibility for other light sources in the vicinity to be similar in appearance to these rapidly flashing white lights. Thus, the EFAS system immediately provides, without mental calculation: (1) identification, (2) direction, and (3) rapid transition from instrument to visual approach. The flashing lights alone do not provide any horizontal reference. Therefore, at each flashing unit position there are five *Par 56* incandescent lamps which can be adjusted in intensity to match the particular weather conditions. The flashing units are observed five to nine seconds before the horizontal bar lights come into view. This establishes roll guidance and completes the transition from instrument to visual approach.

Electrical Circuit

Each EFAS unit consists of a xenon-filled lamp which is designed to give 500 hours of life when operated at 2,000 volts. Xenon emits an instantaneous bright white light when high electrical discharges are made through it. The lamps are placed across a 30-μf capacitor, and the application of an instantaneous high-voltage trigger pulse causes the capacitor to discharge through the lamp, giving a bright white light. There are two *#1616* rectifiers which provide a 2,000-volt d-c potential used to charge the capacitor. A relay connected with a central timing device discharges a smaller capacitor through an ignition-type transformer. This provides the instantaneous high-voltage pulse required to flash the lamp.

Mechanical Characteristics

The electrical components are housed in a waterproof aluminum cabinet, and all parts are chosen to be noncorrosive in a salt-water atmosphere. Tempered glass is used in the front lens to resist breakage. The rear cover is easily removed with a screwdriver, and the inside chassis can be removed by hand, if replacement is necessary. There is a device inside the unit that allows for leveling the reflector even though the unit may be mounted on a platform which itself is not level. All components are made to JAN (Joint Army & Navy) specifications and have been thoroughly tested from −55 to +140 F in an atmosphere which is both humid and is representative of extreme weather conditions.



EFAS centerline approach lighting system at Idlewild as it looks to a pilot bringing his plane in for a landing.

Batwing Antennas Radiate High Power Television Signals

THE TYPE *TY-50/60/70* series vhf television transmitter antennas developed by General Electric (GE) Company consist of stiff steel masts mounting one or more groups of "batwing" style radiating elements. These batwings are connected with 7/8-inch Styroflex feedlines to specially designed junction boxes. Either two or four $3^1/_8$-inch transmission lines (depending upon the choice of operational modes) are mounted on the mast with their bases terminating in $3^1/_8$-inch flanges between the bottom of the lowest bay and the mast base. The upper ends of these transmission lines are connected directly, or by means of quick disconnect "Tee" feeds, to the proper junction boxes.

These antennas are offered with a large variety of power gains in each vhf operating channel. The broadcaster may make his selection based upon coverage requirements, antenna site, location, topography, available power lines, and economy requirements. In short, the broadcaster may select a high gain antenna and a low power transmitter for economical operation; a low gain antenna and a higher power transmitter for optimum coverage of certain types of markets or topography; or a high gain antenna and a high power transmitter for maximum ERP.

The patterns available from the *TY-50/60/70* series antennas are identical to those obtained from the former *TY-26/27/28/30* series antennas.

One, three, four, five, and six bay models with corresponding nominal gains are available in each of the channels 2 through 6. Two, 6, 8, and 12 bay models with corresponding nominal gains are available in each of the channels 7 through 13. The nominal power gain (ratio) of these antennas is one per bay.

With the exception of one and two bay antennas, all vhf antennas in this series are designed to accept the full rated output of a 50-kw transmitter in the average station installation, taking into account the losses expected in diplexing and transmission line runs. Input kilowatt (average) to this series of antennas is rated from 48.4 kw to 55.0 kw with the exception of one and two bay antennas rated at 22 kw input (average). Thus, the broadcaster may select a high gain antenna and feed it with a low power transmitter to effect economies in tube and power line consumption. If he wishes, he may later add higher power amplifiers to raise his effective radiated power and yet not be faced with the necessity of replacing his antenna with one of greater power handling capability.

In normal installations, the horizontal pattern is essentially circular, deviating less than ± 0.5 db under ideal conditions. In normal operation, the pattern will not deviate by more than ± 2.0 db from a circle for any frequency within the operating channel. The vertical pattern is essentially constant throughout the operating channel. It is shaped so as to give the power gains specified in tabular information on power gains and free space field for individual models.

For special location use, the antenna design is easily custom modified, tuned, and tested at the factory to provide horizontal patterns varying from circular to "figure-eight" shapes. A slot diplexer and phasing unit, sold as accessories on special order, are required for this use.

A nominal amount of vertical beam tilt and/or up to approximately 20 db of null fill-in can be supplied optionally to the broadcaster if he so specifies when ordering the antenna. Additional amounts of vertical beam tilt and/or null fill-in may be designed into the antenna by special order of the broadcaster if requested at time of order. Beam tilting and null fill-in may be accomplished by differential phasing and/or a 70/30 power split between the upper and lower groups of bays.

Field tested and proved, this batwing antenna design offers savings in increased safety, operational and maintenance convenience, and economy to the broadcaster.

Its unique and conservative design offers the strongest and stiffest vhf television mast in the industry. Chafing and straining of feedlines is virtually eliminated. Vertical beam swing (with consequent degradations of the received signal) caused by mast bending in high winds is minimized to one degree or less. To date, not a single GE batwing television transmitting antenna mast has failed under the most adverse weather or hurricane conditions.

To prevent mechanical shifting of the radiator elements by ice and wind (with consequent change in pattern and vswr), the "bosses" supporting the radiators are welded solidly to the mast. Each radiator is then spaced at a predetermined distance (depending upon the operating channel) from the mast and adjoining radiators to effect an accurate feedpoint impedance match and the lowest possible vswr. Once so placed, each radiator is solidly and securely bolted to the support "bosses."

Styroflex 7/8-inch feedlines are used for connection between the radiators and the specially designed junction boxes. In addition to an increase in transmission efficiency, the use of these larger diameter feedlines boosts the power handling safety factor and eliminates the possibility of arc-over. Physically and electrically, the feedlines are grounded through the use of "Aero-Seal" clamps and grounding studs spaced at correct intervals along the lines and mast. These studs and clamps assure the careful grounding and spacing of the feedlines in addition to eliminating the possibility of high winds chafing or straining the lines thus assuring reliable operation under adverse conditions.

Gas and moisture proof connections between the Styroflex feedlines and the junction boxes are made by the use of flare fittings, eliminating superfluous reflectometer wells.

The junction boxes, incorporating a unique and novel design, permit achievement of optimum electrical characteristics. Essentially, these units consist of top and bottom plates bolted to a circular ring, the depth of which is varied according to the operating channel. Each junction box and matcher assembly is individually pretested both mechanically and electrically by GE personnel prior to installation. In addition, the correct impedance and vswr characteristics of each junction box are determined and

BATWING ANTENNA, reassembled at installation site, being tested by GE field personnel prior to erection.

checked with its associated feedlines after attachment to the antenna.

Impedance transformers are installed in the $3^1/_8$" transmission line between junction boxes and antenna base. These transformers guarantee an accurate match to the new RETMA 50 ohm input standard.

For 12 bay antennas, two modes of operation may be selected—either single or divided section antenna operation. By use of four transmission lines on the antenna, upper and lower halves of the antenna may be fed separately to effect vertical beam tilting, null fill-in, or for emergency operation in the event of damage to one of the transmission line runs. Vertical beam tilting may be effected easily by a change in phasing between the upper and lower sections of the antenna. Close-in coverage or null fill-in may be effected by use of power splitting between sections, the most common being a 70/30 split which provides 20 db of null fill-in with only a small reduction in total gain. These four lines may be combined in a "combining Tee" at the base of the antenna, with the customary two tower transmission lines, for four tower transmission lines may be installed with the "combining Tee" located either at the base of the tower or in the transmitter building. The latter method makes possible the immediate cut-over of power from the full antenna to half of the antenna in the event of tower line damage. If the combining tees are located on the antenna, installation or removal of the tee feeds is facilitated by use of quick disconnect Tee-feed connections. These Tees are used on both the 8 and 12 bay, high channel antennas.

Antenna performance is protected for years to come through the use of: (1) all brass junctions and stainless steel fastenings, proof against moisture, gas, and electrolytic corrosion; (2) all other hardware rustproofed by the use of heavy zinc-plating and "Cronak" finishing; (3) lightning protection by the use of lightning rods and complete radiator and mast grounding; (4) no high impedance points subject to icing or soot troubles; (5) available deicing heaters and controls in those areas subject to icing; (6) the assembly and testing by GE personnel of all antennas prior to erection; and (7) an accessory nitrogen pressurization kit which will provide protection against internal damage due to moisture and oxidation of the transmission lines.

Information as well as protection is given the broadcaster, plus complete test data on each antenna assembled and tested at the factory. This may be used to compare performance of the erected antenna with that of the antenna prior to shipment.

Low channel, one and three bay antennas are shipped fully assembled. Low channel four, five, and six bay antennas are assembled and tested at the factory. They are then partially disassembled for shipment. At the antenna site the four, five, and six bay antennas may be reassembled and tested under the supervision of GE field personnel, if desired. The high channel antennas, except the 8 and 12 bay models, are shipped fully assembled. Eight and 12 bay high channel antennas are shipped in 2 assembled sections, requiring only a field weld at the antenna site, plus rf and electrical connections across the joint.

Where the antenna has been previously assembled, tested, and approved at the factory, it will be necessary for the broadcaster to build his own test "horses" to test the antenna prior to erection. In these cases, the broadcaster should contact his district product service representative, prior to antenna shipment, for details on vertical and horizontal clearance distances from the ground or surrounding obstructions and to request a copy of General Electric drawing No. *A-7150326* titled: "Suggested Construction of Wooden Horses for Field Assembly and Test of High Channel VHF Antennas." Dimensions and construction details of low channel vhf antenna test horses are obtainable direct from broadcast equipment product service at GE's Electronics Park.

SAGE Electronic Brain Teams with Radar in Pushbutton Air Defense System

A PARTIAL PREVIEW was given recently of the heretofore classified system for the air defense of North America. This experimental combination of radar, radio, computer, and telephone network is centered at the secret Lincoln Laboratory, operated by the Massachusetts Institute of Technology (M.I.T.) for the Department of Defense.

Several radar sites in eastern Massachusetts, one about 200 miles at sea, automatically transmit the course, speed, altitude, and location of all aircraft in the area by microwave radio or telephone lines to a direction center. It is here that the Semi-Automatic Ground Environment (SAGE) apparatus receives, collates, and processes the radar data. Not only are radar data sent to the direction center, but also information from the Ground Observer Corps; flight plans of friendly aircraft, weather information, etc.

The radar information is displayed continuously on 30-inch cathode-ray tubes and all the data are fed into digital computers which are described as "among the largest and most reliable yet built," by International Business Machines (IBM) Corporation. The computers translate all the information into a composite picture of the area's situation in the air and this is shown on radar scopes at the direction center.

The computers also calculate for the operators the most effective use of interceptor aircraft, anti-aircraft, and missiles such as Nike. Through radio data links, all-weather interceptors and long-range missiles are guided automatically to targets by the computers.

The operation of SAGE may be briefly described as follows. When a bomber formation is detected by early-warning radar, its course is shown and it is identified as friend or foe. Assuming these are enemy aircraft, an identification officer selects a weapons assigner to organize the attack against them. The computer gives the weapons assigner complete information about

Future Meetings of Other Societies

Conference on Radio Interference Reduction, Armour Research Foundation of Illinois Institute of Technology, March 6–7, Technology Center, Chicago, Ill.

Passenger Car, Body, and Materials Meeting, Society of Automotive Engineers, Inc., March 6–8, Hotel Statler, Detroit, Mich.

14th Annual Society of the Plastics Industry Canadian Conference, March 8–9, Sheraton-Brock Hotel, Niagara Falls, Ont., Canada.

National Electrical Manufacturers Association, March 12–16, Edgewater Beach Hotel, Chicago, Ill.

National Association of Corrosion Engineers, National Conference and Exhibition Reduction of Corrosion Losses, March 12–16, Hotel Statler, New York, N. Y.

American Institute of Industrial Engineers, 5th Annual Spring Conference, March 15–16, Cleveland Chapter, Cleveland, Ohio.

Steel Founders' Society of America, Annual Meeting, March 15–16, Drake Hotel, Chicago, Ill.

American Trade Association Executives' Washington Conference, March 15–16, Statler Hotel, Washington, D. C.

The American Society of Mechanical Engineers, Spring Meeting, March 18–21, Multnomah Hotel, Portland, Ore.

Regional Reactive Metals Conference, Niagara Frontier Section, American Institute of Mining and Metallurgical Engineers, March 19–21, Buffalo, N. Y.

Production Meeting and Forum, Society of Automotive Engineers, March 19–21, Hotel Statler, Cleveland, Ohio.

Institute of Radio Engineers, National Convention, all professional groups, March 19–22, Waldorf-Astoria Hotel and Kingsbridge Armory, New York, N. Y.

American Society of Tool Engineers, 1956 Industrial Exposition, March 19–23, International Amphitheatre, Chicago, Ill.

Fifth Electrical Engineers Exhibition, Earls Court, Association of Supervising Electrical Engineers, March 20–24, London, S.W.5, England.

13th Annual Pacific Coast Section Conference, The Society of the Plastics Industry, Inc., March 27–April 2, St. Francis Hotel, San Francisco, Calif., and *S. S. Lurline* to Honolulu Oahu, T. H.

Air Force Cambridge Research Center Headquarters, Symposium: Microwave Properties and Applications of Ferrites, sponsored by Air Research Command, Harvard University, and IRE, April 2–4, Harvard University, Cambridge, Mass.

National Science Foundation and Atomic Energy Commission, 6th Annual High Energy Nuclear Physics Conference, April 3–7, Rochester, N. Y.

Canadian Institute of Mining and Metallurgy, Annual General Meeting, April 9–11, Quebec, Ont., Canada.

Symposium for Management on Applications of Analogue Computers, sponsored by Midwest Research Institute, April 10–11, University of Kansas City, Mo.

Institute of Radio Engineers, Spring Technical Conference, April 13–14, Engineering Societies Building, Cincinnati, Ohio.

"Research for Profit" Conference, sponsored by Armour Research Foundation, April 18–20, Illinois Institute of Technology campus, Chicago, Ill.

Protective Relay Engineers, 9th Annual Conference, April 23–25, A & M College of Texas, Electrical Engineering Department, College Station, Texas.

International Union of Pure and Applied Physics, International Conference on Electron Physics, April 23–25, National Bureau of Standards, College Park, Md.

Electrochemical Society, 4th Annual Semiconductor Symposium, April 29–May 3, Mark Hopkins Hotel, San Francisco, Calif.

Society of Motion Picture and Television Engineers, 79th Convention, April 29–May 4, Hotel Statler, New York, N. Y.

the enemy planes, and the defensive weapons he has available. The weapons assigner has several intercept director teams which can be assigned responsibility for individual interceptions.

On the weapons assigner's radar scope, each enemy plane is indicated by numbered tracks, their length and direction showing the plane's speed and course. Also shown are geographical references, available anti-aircraft fire, and airfields. Small squares indicate the points at which the fighters from the fields will intercept the enemy planes and numbers show the minutes to interception. This information is shown in less than a minute after detection.

The intercept directors assign fighters at different fields and the midcourse flight of the fighters is under the control of computer-generated directions sent by radio to the automatic pilot in the lead plane. When the fighters close with the enemy planes in final action, airborne equipment takes over from the computer. At the conclusion of the action, the computer at the center takes over again and guides the interceptors back to their respective bases. The pilot may have to use judgment if something goes wrong; otherwise, he has only to get the plane into the air and land it after the action.

Although the SAGE system is a great advance in our air defense, men are required to supervise and monitor it. Inasmuch as its speed of reporting and processing can be measured in fractions of seconds, its reliability meets military requirements. However, enemy jamming can easily neutralize its effectiveness.

Lincoln Laboratory

M.I.T. Lincoln Laboratory was organized in 1951 in Cambridge, Mass., by the Massachusetts Institute of Technology at the joint request of the U. S. Army, Navy, and Air Force for the primary purpose of mounting an all-out technological attack on some of the problems of continental air defense. The Laboratory is a tri-partite organization jointly supported by the three armed services through the Air Research and Development Command after the report and recommendations of a study of the effectiveness of United States defense against air attack, by a special Air Force appointed study group known as the Air Defense Systems Engineering Committee (ADSEC).

Soviet possession of nuclear weapons and the ability to deliver them to the North American continent rendered the United States vulnerable to large-scale air attack for the first time in history. ADSEC's reassessment of air defense potential indicated an urgent need for more effective defense.

The initial nucleus of Lincoln personnel was composed of scientists and technicians already engaged in related work. From the M.I.T. Research Laboratory of Electronics came groups working on long-range radio communication, radar, and solid-state physics; from the M.I.T. Digital Computer Laboratory came the Whirlwind I computer groups working on real time control applications of computers, random access magnetic storage, and computer design; from various departments of M.I.T. came specialists in mathematics, physics, servomechanisms, and mechanical engineering; from outside M.I.T. were brought scientists experienced in pulse-coded data transmission and other pertinent technological and scientific areas.

Lincoln Laboratory is managed by members of M.I.T.'s faculty. Liaison to the Institute is maintained through Adm. Edward L. Cochrane (Ret.), vice-president for industrial and Government relations.

Dr. M. G. Holloway, an eminent nuclear scientist with a record of important contributions to the development of atomic weapons over a 12-year period of service at the Los Alamos Scientific Laboratory, is director of the Laboratory.

Dr. G. E. Valley, Jr., associate professor of physics at M.I.T. and a specialist in nuclear physics and cosmic radiation, is associate director of the Laboratory.

Heads of research divisions include Dr. C. F. J. Overhage; Dr. W. H. Radford,

U. S. Navy Photo

HIGH-SPEED MEMORY UNIT (above) is made up of three-dimensional array of ferrite cores. Long-range search radar site (lower) on eastern coast of Massachusetts. Super-Constellation (upper) equipped for airborne early warning radar

rofessor of electrical engineering at M.I.T.; erome Freedman, Dr. S. N. VanVoorhis; nd Dr. J. W. Forrester.

A Joint Services Advisory Committee with representation from each service meets regularly with the Lincoln management. The current members of this committee are: Lt. Gen. D. L. Putt, USAF, chairman; Col. J. K. Johnson, USAF, recorder; Brig. Gen. J. P. Daley, USA; Brig. Gen. F. F. Uhrhane, USA; Rear Adm. R. Bennett, II, USN; and Capt. E. H. Eckelman, Jr., USN.

In addition to specific projects such as SAGE, one of the significant areas of work at Lincoln is radar research and development for land, sea, and airborne uses. Studies are being made to improve the transmitting, receiving, and display components. Increasing useful range and improving operation under unfavorable weather conditions are other radar research objectives.

Development of the ionospheric and tropospheric scatter systems of long-range radio communications, following fundamental work in physics and engineering, is another Lincoln project. These systems provide ultra-high frequency beyond-the-horizon radio communication of extremely high reliability.

A general listing of specific kinds of research and development at Lincoln would include digital data transmission, solid-state physics including both transistors and magnetic ferrites for digital computer and radar applications, improved ground and airborne radars, long-range radio communications, anti-aircraft weapons systems, theory of sample data servo systems, psychological research on training and operator relationships to equipment and systems analysis, simulation, and evaluation.

Facilities at Lincoln and its affiliated M.I.T. Barta Building in Cambridge include a semiconductor physics laboratory, physical chemistry laboratory, metallurgical and ferrite laboratories, low temperature research facilities, a mechanical engineering group specializing in structures, electromechanical design and heat transfer, vacuum tube construction shop used for special cathode-ray display tubes, microwave research facilities, three large-scale digital computers, extensive shops, drafting rooms, and a photographic laboratory.

Further facilities located in various parts of New England and the United States include more than 20 field stations for testing and development work, an experimental radar and communications network under M.I.T. operational control covering eastern Massachusetts for air defense tests, and experimental test aircraft support from the Air Force and Navy.

Air Force Cambridge Research Center

The Air Force Cambridge Research Center (AFCRC) is one of 10 special centers assigned to the Air Research and Development Command to carry out its mission of attaining and maintaining qualitative superiority in equipment for the U. S. Air Force. The Center is under the command of Maj. Gen. R. C. Maude.

For the past two years, AFCRC has gradually centralized its activities at Laurence G. Hanscom Field, Bedford, Mass. Although several highly specialized laboratories will be retained in other areas, the main research efforts of the Center will be conducted in modern buildings located less than half a mile from the Lincoln Laboratory.

Display consoles of the Whirlwind I computer, part of the SAGE North American continental defense system.

The mission of the Center is twofold: First, through its three major directorates, it accomplishes research, development, and test in the fields of electronics, geophysics and human factors. The three components—Electronics Research Directorate, Geophysics Research Directorate, and Operational Applications Laboratory—carry out their missions within their own laboratories, or through work done on contract by universities, research foundations, and industry. Second, the Center provides for administration and support of the Lincoln Laboratory, operated under contract by the Massachusetts Institute of Technology.

The bulk of the Center's support to Lincoln (including materiel, flight test, and the manning of an experimental air defense network) is provided by the 6520th Test Group (Support). Using the flight facilities at expanding Hanscom Field, planes of many types assigned to the 6520th Test Group (Support) fly missions in support of the Lincoln Laboratory. With the Lincoln Laboratory, the Raytheon Laboratory, the buildings of the Commonwealth of Massachusetts, the recently added 49th Fighter Interceptor Squadron of the Air Defense Command, the 2234th Air Reserve Training Center, and several other smaller components, Hanscom Field is now a vital defense installation.

Loyola School of Dentistry Successfully Teaches via Television

THE SCHOOL OF DENTISTRY, Loyola University, Chicago, Ill., $2\frac{1}{2}$ years ago pioneered in the use of closed-circuit television to help teach dental students.

At present, according to Dr. A. R. Baralt, Jr., dean of the Dental School, television is used to teach more than a dozen courses and the results have far exceeded early expectations.

The program was devised by Dr. Baralt and J. E. Blickenstaff, the school's visual aids director.

Every floor and every classroom is now wired for closed-circuit television reception, with programs originating in either surgery or the school's television studio. Two clinical floors of the building, three laboratories, a post-graduate room and two amphitheatres also are connected to the closed-circuit system to facilitate transmission of visual and audio impressions throughout the school.

An example of television's tremendous value to dental instruction is pointed out by Mr. Blickenstaff, when referring to its use in conjunction with a once-a-week sophomore lecture-demonstration course in operative dentistry which is conducted by Dr. F. M. Amaturo, faculty secretary and associate professor of operative dentistry at Loyola.

Because of the inherent smallness of materials under discussion, the television camera is used to project close-up images on large-screen receivers placed in the lecture hall.

Adjacent to the hall is the school's television studio, equipped with a Dage Model 101 television camera, lights, a monitor, and the other necessary equipment. A three-lens turret on the camera facilitates flexible handling of different subjects.

From this studio, Dr. Amaturo conducts his lecture-demonstration, seated at a small table on which he places large models of teeth and whole "plates" to help in his description of operative techniques. By watching a nearby monitor, he can see exactly what the students in the amphitheatre see, and adjust his actions accordingly.

The television camera is operated by Mr. Blickenstaff, who also handles lighting and controls audio conditions.

Dr. Baralt said he is particularly pleased by the way closed-circuit has reduced the time teachers formerly needed for lecture-demonstrations. In the past, he pointed out, groups of only five or six students would cluster around a table or "patient" to see,

OPERATIVE DENTISTRY lecture-demonstration by Dr. Frank M. Amaturo (left, seated) on closed-circuit television which is being used by Loyola University's School of Dentistry, help teach many subjects.

TV CLOSE-UPS (above) seen on two large-screen monitors gives entire class of 94 students intimate view of teacher's operative technique.

first-hand, the methods being described by the lecturer.

This meant that the instructor would have to repeat the demonstration as many as 20 times, to accommodate all students.

Now through the medium of closed-circuit television, an entire class of 100 students can watch the demonstration at the same time, thereby saving as much as three weeks time for one instructor.

Dr. Baralt explained that there are other advantages in addition to time saved. Standardization of technique is much more easily accomplished, since he needs to do an operation only once, rather than many times. Also, the enthusiasm which all teachers bring to their lecture-demonstrations is not diminished or dissipated by successive repeats of the same material.

He pointed out that because of television, teachers found they were paying more attention to visual systemization, which put greater order and clarity into their demonstrations.

Mr. Blickenstaff feels students' attitudes are very favorable toward the televised lecture-demonstrations. They receive better instruction than previously was possible and in less total time, he said.

In addition to being used to teach Operative Dentistry, closed-circuit television is also used at Loyola's School of Dentistry in the following courses: Dental Materials; Anatomy; Physiology; Orthodontia; Oral Surgery; Prosthetics; Crown and Bridge; and in numerous clinical and laboratory demonstrations.

Mr. Blickenstaff says that the television equipment has more than paid for itself. He said that $3,500 was spent originally for equipment, and that approximately $2,000 more was invested in additional equipment over the months.

"But this investment has been insignificant," Mr. Blickenstaff said, "compared to the many audio-visual advantages we have gained from our closed-circuit television system."

Transistor Developed with Unsurpassed High Frequency Performance

A MAJOR ACHIEVEMENT that opens new possibilities in electronics was reported recently by Bell Telephone Laboratories. This is a major breakthrough in transistor technology—new fabricating techniques for an entirely new kind of transistor.

The new device's performance at very high frequencies surpasses that of any other transistor. Development is under way preliminary to manufacture.

Key to the new fabricating techniques is the development of controls over microscopic chemical layers. The heart of the new transistor is a layer 50 millionths of an inch thick.

The new techniques involve the adaptation of the chemical process of "diffusion" used in treating silicon for the Bell Solar Battery. Diffusion is a process by which minute amounts of impurities are introduced in controlled amounts into a material.

The transistor consists of a three-layer chemical "sandwich." The center layer is known as the "base." The other two are the emitter and collector layers. The narrower the base layer can be made the higher the frequency at which it will operate. Diffusion provides a high degree of control of such microscopic dimensions.

Because of its very high frequency characteristics the new transistor appears to be ideally suited for application in guided missiles and electronic "brains" for military and computer uses.

The new transistor could amplify 2,500 telephone conversations simultaneously on a telephone line. This is three times as many as could be handled by the best previous transistor. It is also expected to be extremely useful in television transmission, which requires a much wider communication channel than a telephone conversation.

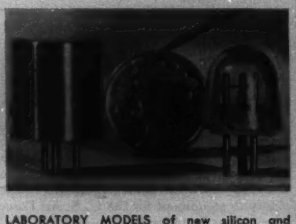
Color television sets offer a possibility for the new transistor, too. Although vacuum tubes are now doing this job, the new transistor is much smaller, requires less power, and does not heat up like a tube. It is expected to have a longer life than a vacuum tube. The new device has been made of both germanium and silicon, with striking improvements in both.

C. A. Lee, of Bell Laboratories, is chiefly responsible for perfecting the techniques with germanium. C. S. Fuller and M. Tanenbaum have applied the diffusion technique in making the new transistor from silicon. William Shockley and G. C. Dacey were instrumental in directing work that led to this development.

Transistor performance has been measured in two principal ways. One criterion has been the number of oscillations or self-generated electrical pulses per second. A second criterion, considered by Bell scientists to be more significant, is the number of voice or communication channels that can be amplified. In this latter category, they report that the new transistor is unequaled.

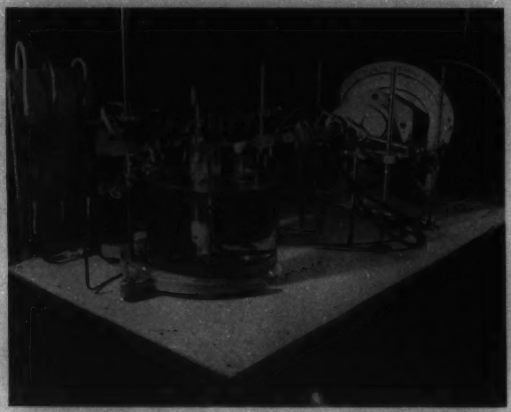
Experimental units of the device made at Bell's Murray Hill, N. J., laboratories have amplified by 100 to 1 currents across a 20-mc-wide band. Either the amplification or the number of communication channels can be made three times that of any other transistor. The number of communication channels or pathways varies with the degree of amplification. For example, if the frequency band were cut in half, thus halving the number of channels, there would be twice as much power amplification.

Currently available transistors have a frequency cutoff of 1–10 megacycles, and several recently announced transistors have had a frequency cut off between 100 and 200 megacycles. Thus far, the new transistors have been found to reach a cutoff between 500 and 600 megacycles. Even though the effective operation of many military elec-



LABORATORY MODELS of new silicon and germanium transistors announced by Bell Telephone Laboratories shown in comparison with U. S. dime. Silicon transistor, with brass cap, is at left and germanium transistor, with glass cap is at right. Models give only impression of what final transistors will look like; smaller units will eventually be manufactured. Performance of the new transistor at very high frequencies surpasses that of other transistors.

TECHNICIAN performing one of the operations in the fabrication of the new germanium transistor. Electrical contacts are made to germanium by vaporizing a metal onto the surface of the material. Later, wire leads are attached. The bar of germanium is held in vise under vacuum in jar.



APPARATUS used at Laboratories to control, automatically, diffusion process used making new transistors. Panel at left controls flow of chemical impurities and gas through the tubes coiled in tank of water in center. From tubes, impurities are introduced into oven at right, where, under gas and at carefully regulated temperatures, they are diffused into material. An attendant can easily check the progress.

tronic devices is in a much lower megacycle range, the higher frequency cutoff would provide a greater number of communication channels or more amplification than previously possible.

In making the new transistor, an impurity must be introduced only once into the growing crystal. The fully grown crystal receives two other doses of impurity in the easily controlled diffusion process, which is more precise than the older "double-doping" and alloy processes. Both of these processes require control, at very high temperatures, of the boundary between liquid and solid germanium or silicon, in order to determine the dimensions of the base layer. This is very difficult compared with controlling diffusion, in which the desired foreign atoms move through the solid crystal to the required depths.

United Nations To Publish 16 Volumes

The most complete survey of the status of development of nuclear power in the world for peaceful purposes will be published by the United Nations in 16 volumes, "Proceedings of the International Conference on the Peaceful Uses of Atomic Energy." The first available part will be Volume 3, on "Power Reactors."

All the volumes of the series in English will be ready by early 1956. Prepublication price in the United States is $110 for the entire set. After completion of publication of all volumes, the price will be $130 per set.

The editorial staff consists of: Robert A. Charpie, U. S. A.; Donald J. Dewar, Canada; André Finkelstein, France; John Gaunt, United Kingdom; Jacob A. Goedkoop, Netherlands; Elwyn O. Hughes, Canada; Leonard F. Lamerton, U. K.; Aleksandar Milojevic, Yugoslavia; Clifford J. Mosbacher, Jr., U. N. Staff; Cesar A. Sastre, Argentina; and Brian E. Urquhart, U. N. Staff.

Visitors may obtain the volumes as they become available at the U. N. Bookshop in the Headquarters Building. Prices and approximate number of pages are listed, along with the title of each volume.

Volume 1, "The World's Requirements for Energy: The Role of Nuclear Power," $8, 544 pages.

Volume 2, "Physics, Research Reactors," $8, 520 pages.

Volume 3, mentioned earlier as already available, $7.50, 400 pages.

Volume 4, "Cross Sections Important to Reactor Design," $7.50, 416 pages.

Volume 5, "Physics of Reactor Design," $9, 700 pages.

Volume 6, "Geology of Uranium and Thorium," $9, 736 pages.

Volume 7, "Nuclear Chemistry and the Effects of Irradiation," $10, 776 pages.

Volume 8, "Production Technology of the Materials Used for Nuclear Energy," $10, 768 pages.

Volume 9, "Reactor Technology and Chemical Processing," $10, 864 pages.

Volume 10, "Radioactive Isotopes and Nuclear Radiations in Medicine," $8, 640 pages.

Volume 11, "Biological Effects of Radiation," $8, 480 pages.

Volume 12, "Radioactive Isotopes and Ionizing Radiations in Agriculture, Physiology, and Biochemistry," $9, 704 pages.

Volume 13, "Legal, Administrative, Health, and Safety Aspects of Large-Scale Use of Nuclear Energy," $7, 400 pages.

Volume 14, "General Aspects of the Use of Radioactive Isotopes; Dosimetry," $6.50, 312 pages.

Volume 15, "Applications of Radioactive Isotopes and Fission Products in Research and Industry," $7.50, 400 pages.

Volume 16, "Record of the Conference," $5, 350 pages.

Complete sets or individual copies can be obtained from United Nations official sales agents in the various member countries.

In the United States, orders should be sent to: International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N. Y. For additional information, write: Sales and Circulation Section, United Nations, New York, N. Y.

Top-of-Range Cooking Thermostatically Controlled

A complete holiday meal—everything from chicken fricassee to crepe suzettes—was prepared in a recent demonstration of thermostatically controlled, top-of-the-range cooking before the New Jersey Home Economics Association.

Miss Rhea Shields, home economics director for Robertshaw-Fulton Controls Company, described the "thermal eye" temperature control on top of the range as "the first cousin to the oven heat control." This revolutionary new control now is featured on 1956 models of various well-known "makes" of kitchen ranges, she explained.

Scorched pans, boil-overs, and scouring, are eliminated, and it prepares food better.

It eliminates the necessity of paying close attention to what goes on on top of the range—the control turns down the gas when the dialed temperature is reached, turns the flame up again as needed. Thus, thermostatic controls mean inexpensive cooking "because the heat is on only when you need it."

Demonstrating these points, Miss Shields prepared an entire meal in the home economics kitchen at Public Service Auditorium where the meeting was held.

THERMAL EYE controls temperature on top-of-range cooking demonstration which will revolutionize meal preparation methods.

She showed how the "thermal eye," which is located where the bottom of the cooking vessel touches the burner, controls the temperature.

When the dial is turned to 200 degrees, for example, the flame comes on and stays on until the food is 200 degrees. Then the control turns off the flame and keeps the food at 200 degrees until needed.

The meal prepared by Miss Shields included "baked" potatoes—cooked in a dry pan, unwrapped, on top of the stove, at 375 degrees. Frozen green peas to which a little water and butter were added were dialed at 205 degrees.

Rolls were kept hot at 190 degrees all through the demonstration without turning once. Bread custard also was made on top of the range at 190 degrees. Chicken fricassee was the chief item on the menu.

Custards—most difficult to make on top of the range, without a double-boiler—can be cooked on top of the range now instead of in the oven.

A colorful Bing cherry sauce was made for the custard. Anchovy hors d'oeuvres and sausages also were prepared. But the dish that brought actual applause from some 50 home economics specialists who were present was crepe suzettes, made easily by setting the control at 340 degrees.

And, of course, there was coffee.

"The old statement that coffee makes the meal now has competition," Miss Shields said. "We now say that the 'thermal eye' makes the meal—delicious."

Airborne Operations Radio Developed by Signal Corps

A versatile long-range radio for jeeps, tanks, and trucks that goes on the air moments after being parachute-dropped in its vehicle has been developed by the Signal Corps Engineering Laboratories of Fort Monmouth, N. J., and the Collins Radio Company, Cedar Rapids, Iowa.

Engineered to replace models used in World War II and in Korea, and up to four times more powerful, the set combines advanced design with better parts to pack more power into a smaller space. It covers more distance, and gives clearer signals.

Identified in military nomenclature as the AN/GRC-19, the new Signal Corps transmitter-receiver can do many things formerly impossible with any combination of sets in its class.

In forward combat areas its extremely wide frequency range offers a better opportunity for infantry, artillery, and armor to talk to each other, knitting these units into a harder-hitting tactical team.

Messages now can be sent over mountains or other barriers without relay radios. An airborne group parachuting a few hundred miles inside enemy lines can report almost immediately to command headquarters. Or friendly troops in separated valleys—with a division often spread 40–50 miles as in Korea—will have instant communications.

Both voice and radio teletype messages can be sent and received at the same time. A few added parts link in the Signal Corps lightweight 100-word-per-minute teletypewriter—an impossibility with earlier sets. The transmitter can be remotely controlled from up to 75 feet away.

The new radio has seven channels pre-set as in push-button models. The operator merely switches to the one he wants, presses his microphone button, and talks. Releasing his microphone button, the receiver cuts in automatically.

For any other channel, he turns a dial to the right number on the panel. It looks like the car's total mileage indicator. A few seconds later a red light flashes ready.

A beginner can be taught in 10 minutes how to use the set. The radio does the rest by automatically tuning itself and its antenna.

Upkeep in the field is as easy. Any defective part is unplugged and another inserted. Replaced parts are repaired later at depots.

Stability has been so greatly improved that crystals are no longer needed to keep the new set tuned on a channel. This does away with substituting crystals whenever new frequencies are wanted. Earlier models depended on these quartz devices to lock in the wanted frequency and prevent drifting off channel.

The new radio is powered by its vehicle's regular battery, plus a special generator and fits snugly into its reserved space in reconnaissance cars, tanks, and jeeps.

It works in temperatures from −40 to +149 F, in rain, sleet, or snow. By reversing a few small ventilating covers it can be sealed for long periods in all kinds of weather.

Largest Stainless Steel Skyscraper Completed

The Socony Mobil Building, occupying the square block between 41st and 42nd Streets, and Lexington and Third Avenues is the first office building in New York's Manhattan to be supplied with 265/460 volt current. This simplifies installation and reduces costs of supplying electric power.

The electrical engineering was handled by the Edward E. Ashley firm. Elevators and escalators were installed by the Otis Elevator Company. The Carrier Corporation supplied the air conditioning equipment which was installed by Kerby Saunders, Inc., who also installed the heating and ventilation units. Electric installations were made by Fischbach and Moore, throughout the building.

Approximately 750,000 pounds of 0.037 inch thick 18-8 chromium nickel, type 302 stainless steel were used in the building. This stainless was annealed, pickled in acid, then lightly cold rolled to give a moderately bright uniform surface, and the sheets shipped carefully packed in flat crates with paper between stainless sheets to protect them from scratching or staining.

Welding used in the erection of the stainless skin and windows approximated 3,000 feet. The Airco welding equipment and cutting torches were supplied by Air Reduction Co., Inc., one of the future tenants of the building.

Vertical transportation will be provided for the occupants of the skyscraper by 32 Otis Autotronic-without-attendant type passenger elevators plus two escalators, four-feet wide, which will run from the shop line of the concourse to the lobby on the street level. All parts and trim of the elevators and escalators are of stainless steel. The elevators will vary in speed from 500 to 1,200 feet per minute (fpm) with 3 service and 1 freight signal control. The escalators can be adjusted in speed either to 90 or 120 fpm. Each group of elevators is automatically operated by a supervisor who merely turns the traffic flow dial to select a suitable operating program for the traffic needs of the

moment. Cars are then automatically dispatched at adjusted intervals to the various floors. A load weighing device under the floor of each elevator operates in such a way as to cause a filled car to be dispatched ahead of time from a terminal and to run express, stopping only for car calls. An electronic detector stops and reverses both doors of the elevator simultaneously when a passenger is within a few inches of the leading edge of either door. When the normal closing time of the door is appreciably delayed, a loud buzzer sounds in the elevator and the doors proceed to close at a reduced speed, gently but firmly nudging passengers out of the entrance.

To add to the comfort of tenants and visitors to the building, 1,300 Yale No. 90 series door closers will eliminate the annoyance of slamming doors, and will help to assure the utmost efficiency from the air conditioning system throughout the building by their positive closing action.

The windows in the building are water and air tight. A double gasket of polyvinyl chloride (a plastic) was electronically welded between the stainless steel sash and frame, making the windows leakproof. The window prototype was hurricane tested in Miami, Fla., before being installed throughout. The mitred corners of each window were arc welded using a thin tungsten electrode within an argon gas shield. The outer frames are reinforced with triangular stiffeners spot welded to the frame and jamb.

The Committee of Stainless Steel Producers of the American Iron and Steel Institute at 350 Fifth Avenue, New York, N. Y., have been keeping up-to-date data on the largest metal-clad building erected in the world, and can be of further assistance if additional information is required.

Donation to Speed Scientific School for Construction of Building

Speed Scientific School was the recipient of a gift of $450,000 toward construction of a building for Civil and Electrical Engineering donated by Mr. and Mrs. W. S. Speed. This is a continuation of the gifts of the Speed family which now total in excess of $1 million, as announced by Dean R. C. Ernst of the school. The growth of the Speed Scientific School has been closely related to the generosity of the Speed family, since its establishment in 1925.

Recording and Playback Head Tops Four-Million CPS

Development of a new magnetic recording and playback head capable of handling over 4-million cycles per second at a tape speed of 20 feet per second was announced in Cleveland today by William G. Laffer, president of Clevite Corporation.

This tiny component employs a nonmetallic structure not heretofore used in this field and will greatly extend the use of magnetic recording in new areas of technology because of its extraordinary ability to record and reproduce densely stored magnetic information, Mr. Laffer declared.

Nearly 20,000 cycles can be recorded on each inch of a magnetic tape, an achievement considered impossible only a few years ago, he said.

The new magnetic head will improve the techniques of recording television programs on magnetic tape, rather than on film, for later broadcast. It will also more than double the amount of information that can be recorded in the magnetic storage devices which are essential parts of many electronic computers. It also opens new horizons in certain advanced types of military equipment.

Mr. Laffer said sample heads will soon be available to industry through Brush Electronics, Clevite's second largest operating unit, which is the country's leading supplier of high quality magnetic recording and playback heads for industrial and home equipment.

The device was developed by Otto Kornei, head of the magnetic components section at the Clevite Research Center, one of the nation's leading authorities on disc and magnetic recording, and holder of more than 20 patents in that field.

"Tube-In-Strip" Added to Revere Mill Products Line

A new mill product in the form of a single strip, or sheet, of solid copper, brass, or aluminum in which tubes are inflated to desired running lengths in a variety of shapes or sizes has been announced by J. M. Kennedy, chairman of the board of Revere Copper and Brass Inc.

Designated as "Tube-In-Strip," the new product is said to have almost limitless and immediate applications in the heat exchange field, including refrigeration and air conditioning, chemical, food and petroleum processing, automobile radiators, water heaters and coolers, gas heaters, radiant panel heating, and electronics, among others.

As produced, these coils and sheets of Tube-In-Strip are not discernibly different from the standard strip and roll products normally produced in the rolling mill. However, this new material has incorporated within it expandable portions which can be inflated by the user into continuous running lengths of tube of whatever size and spacing or combinations of sizes and spacings might have originally been designated. Except for the expandable portions, the metal is a solid strip of metal derived from a suitably treated casting. The product does not consist of two pieces of metal brazed, welded and rolled together. It can be stamped or drawn into desired shapes prior to the expansion of the channels. The expanded channels can be made circular in section, or during the expansion operation the metal can be forced into dies for the purpose of producing other than circular sections. It is also possible to inflate channels on one side of the strip or sheet only, leaving the other surface flat.

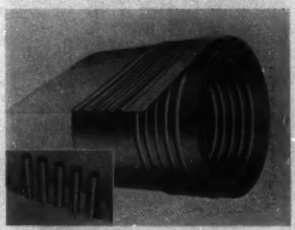
The basic method of producing this material is covered by pending patent applications and manufacturing procedures have been developed for copper and brass, the copper base alloys in general, aluminum and aluminum alloys, zinc, and other ferrous and nonferrous metals.

Mr. Wilkins said that Tube-In-Strip can be furnished exactly as other sheet metal mill products of Revere, in long coils or in cut flat sheets in widths up to 16 inches at present and wider later, the determining factor being the size of the casting billet from which the product is rolled to its desired width or gauge.

Revere plans to ship Tube-In-Strip to the consumer uninflated, thus making possible substantial shipping economies because it will be handled just as easily as sheet metal products when shipped in coils or in sheets;

FOR REFRIGERATION this new product can be inflated on one side only by expanding in appropriate dies. A sample of a section of Tube-In-Strip formed for possible automotive use—in car or truck radiator. Coils of metal with a corresponding pattern of channels can be supplied in copper, brass, or aluminum.

BENDING PROPERTIES are easily seen in the inflated Tube-In-Strip shown here which was formed on multiple die and hand bends after inflation using normal tube bending techniques. Product is shipped by Revere to customer uninflated in coils of strip or flat sheet.



TUBE-IN-STRIP can be inflated in a coil of any desired length, as above. This new Revere mill product is ordinarily shipped uninflated in coils. Part of coil in the picture has been uninflated. A suggested manifold assembly of Tube-In-Strip shows a close-up of the end preparation with web cut away (inset).

This is possible because inflating techniques are flexible and generally simple. For example, for thin-walled tube air pressure may be entirely adequate while for heavy walls hydraulic means of inflation may be better.

Tube-In-Strip can be joined by means of normal commercial techniques. Manifolds, for either series or parallel flow, are easily produced either before or after inflation, and return bends can be brazed, soldered or welded readily.

Sales Music in Every Grocery Store

Background music to increase sales and employee efficiency in almost every grocery store and supermarket may soon be a reality because of a low-cost, mass-produced background music system now being introduced.

Called COMAX, and manufactured by COMAX, Inc., 333 West Excelsior Blvd., Hopkins, Minn., this device plays approximately six hours of continuous music before the mechanism raises the entire stack of records and replays them, giving continuous music without attention all day long.

Because ordinary 45-rpm extended play records are used, it is possible to choose music fitted to the season, time of day and business conditions merely by changing the selection of records. The unit is also used as a public address system and comes complete with a desk microphone.

The machine has a capacity of 25 records for approximately 6 hours of continuous play. The tone arm plays both sides of each record automatically and never repeats the same selection twice in succession. The three basic actions of the stacking mechanism, tone arm movement, record changing, and restacking, are actuated by electromechanical clutches. Power is supplied by a 2-pole motor and the turntable is powered by a separate continuous-duty type of 4-pole motor.

The basic model is equipped with a 15-watt amplifier, sufficient power to handle approximately 20 indoor speakers. Other models are available without desk microphone and amplifier for use where there are already amplifiers available. Output impedences are 4, 8, 16, 250 and 500 ohms and there is a 70-volt constant voltage tap.

BACKGROUND MUSIC and public address system, utilizing extended-play 45-rpm records plays both sides of 25 records before restacking and starting over completely automatically.

Awards Established for Welding Progress

The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, is offering $20,000 in cash awards for ideas or suggestions that will accelerate progress in arc welding. Residents of the United States or its possessions are invited to submit ideas to the Foundation on any aspect of arc welding that can be used to advance welded design, welding engineering, or the general application of the arc welding process. No restrictions are placed on either the nature or the extent of ideas that may be submitted for award. The $20,000 will be distributed in 20 awards with a top award of $5,000, others will be on a declining scale. All ideas must be submitted by July 30, 1956.

Dr. E. E. Dreese, chairman of the Foundation, describes the offer as an exploratory program to discover ways in which arc welding can continue to progress. Welding is widely used in making machinery of all types, erecting buildings, bridges, and other structures and for maintenance work, generally in industry, business, and farming. The Foundation seeks to stimulate continuous progress in all of these fields by exploring all ideas which will contribute to the objectives for which it was established in 1936.

Complete information and rules are available from The James F. Lincoln Arc Welding Foundation, which is located in Cleveland 17, Ohio.

Oak Ridge Institute Nuclear Studies Activities Calendar

Listed in date order are the various courses offered at the Oak Ridge Institute of Nuclear Studies (ORINS) which is sponsored by the Atomic Energy Commission.

In addition, the Oak Ridge School of Reactor Technology is now accepting applications for enrollment in the 1956–57 session.

Date	Course
Mar. 9–10	5th Oak Ridge Regional Symposium: "Atomic Energy and Agriculture," Tuskegee Institute
Mar. 12–23	11th Veterinary Radiological Health Course, Oak Ridge
Mar. 15	6th Oak Ridge Regional Symposium: "Atomic Energy and Science," University of Arkansas, Little Rock
Mar. 16	7th Oak Ridge Regional Symposium: "Atomic Energy and Science," University of Arkansas, Fayetteville
Apr. 16–May 11	50th Basic Course in Radioisotope Techniques, Oak Ridge
Apr. 17–18	Conference on "Atomic Energy and the South," Atlanta
Apr. 19	Conference on "Atomic Energy and the South," Oak Ridge
May 14–June 8	51st Basic Course in Radioisotope Techniques, Oak Ridge
June 11–July 6	Summer Institute for Secondary-School Science Teachers, sponsored by NSF at ORINS
July 9–August 3	Summer Institute for College and University Science Teachers, sponsored by NSF at ORINS
Aug. 6–31	52nd Basic Course in Radioisotope Techniques, Oak Ridge
Sept. 3–28	53rd Basic Course in Radioisotope Techniques, Oak Ridge

The School is a division of the Oak Ridge National Laboratory, which is operated by Union Carbide and Carbon Corporation for the U. S. Atomic Energy Commission. Industrial organizations and Government agencies are invited to sponsor people from their technical staffs for this 50 week training program in nuclear reactor engineering. The deadline for receipt of applications is March 12, 1956; the session begins on September 10, 1956. Further information and application forms may be obtained from the Director, Oak Ridge School of Reactor Technology, Oak Ridge National Laboratory, P. O. Box P, Oak Ridge, Tennessee.

International Conference on Large Electric Systems

The International Conference on Large Electric Systems (C.I.G.R.E.) will hold its 16th Biennial Convention, from May 30th to June 9th, in Paris, France.

This international association has at present 2,000 permanent members belonging

to 43 countries, and plays a very important part in the discussion and diffusion of improvements in the electrotechnique as regards large power plants and high voltage transmission lines.

It has become the international rendezvous of many specialists, and its conventions provide useful information to all engineers wishing to be kept informed of the latest improvements. Its previous convention, held in 1954, was attended by 1,529 participants belonging to 50 countries.

There will be 116 papers offered and discussed in 1956. The two languages used for the papers and discussions will be French and English: specialized translators and interpreters will enable any person having a good knowledge of one of these two languages to derive great benefit from attending.

The subjects to be discussed are: generators, transformers, circuit breakers, high voltage cables, towers and tower foundations, overhead lines and vibrations, insulators, protection and relaying, system stability-load and frequency control, extra high voltage lines, and d-c transmission at extra high voltage.

The C.I.G.R.E. is represented in the United States by the U. S. National Committee—C.I.G.R.E., 50 Church Street, Room 1777, New York 7, N. Y.

President of the organization is Philip Sporn; H. L. Melvin is vice-president; and I. W. Gross is secretary treasurer.

Industrial Research Fellowship Offered by IBM

International Business Machines Corporation (IBM) has announced that it will award industrial research fellowships to enable recipients to continue their academic research programs beyond the doctoral level. The grants will be made annually by a special awards committee headed by Dr. A. L. Samuel, research advisor at IBM, and assisted by a panel of scientists and educators.

The program will support significant research which might not otherwise be undertaken and although projects need not have direct bearing on IBM's development program, preference will be given to proposals which fall within the company's broad range of interest and can be continued without difficulty in IBM research laboratories.

Fellows will be provided with working space at the company's Poughkeepsie Laboratory, where they will be permitted to attend internal seminars and meetings and share in the use of all facilities, including the IBM *704* Electronic Data Processing Machine installed there. They will receive financial support, individually determined, and will be provided with the full-time assistance of one or more technicians, as required by their programs.

In addition to Dr. Samuel, the following have been appointed to the IBM Post-Doctoral Fellowship Awards Committee: Dr. W. J. Eckert, director, Watson Scientific Computing Laboratory; Dr. L. P. Hunter, manager, Physical Research Department, IBM Research Laboratory, Poughkeepsie; Nathaniel Rochester, manager, Information Research Department, Poughkeepsie Laboratory; and Dr. L. H. Thomas, senior member, Watson Scientific Computing Laboratory.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Electrical Oddities

To the Editor:

Last Fall an executive of the American Water Works Association (AWWA) was speaking of the cost of water per ton as against other commodities, and I told him he should use a really valuable product where the "value added in manufacture" was truly large. When I suggested the "weight" and cost per ton for kilowatt-hours, he thought I was trying to pull his leg, so I had to make good. I had never seen any figures as to the "weight" of a kilowatt-hour, and not being able to find them at the local library, I had to make my own calculations (35 years from my EE). Attached is a set of the calculations, and if they are in error, what is a few billion, more or less, among electrical engineers? I have applied for no copyright on it, so if some enterprising utility wants to use it as a basis of charge in this age of increasing use of electrical energy, so let them do it.

Yours truly,

B. J. GEORGE (M '43)
(Registered Professional Engineer Missouri No. E-81)

P. S. Water can be bought at 5–10c per ton.

How Much Does A Kilowatt-Hour Weigh?

1. Weight of the Electron:
   - A. "Standard Handbook for Electrical Engineers" (1949)
     Mass of an electron = 0.911×10^{-27} grams.
   - B. "Engineering Electronics," Happell & Hesselberth (1953)
     "Rest" Mass of an electron = 9.11×10^{-31} kg.
   - C. "Primer of Electronics and Radiant Energy," Coverly (1952) "More than 28 billion, billion, billion to weigh an ounce."
   - D. Calculation of electrons per pound:
     (1) One pound = 16 ounces = 16×28.3495
     $= 453.6$ grams

     $$\text{Electrons per pound} = \frac{453.6}{0.911 \times 10^{-27}}$$

     $= 497.9 \times 10^{27}$
     $= 50 \times 10^{28}$ (approximate)
     (This is 31×10^{27} electrons per ounce.)
     (2) Results are the same as for foregoing (1).
     (3) 28 billion, billion, billion = 28×10^{27} electrons per ounce, which checks (1) and (2).

2. Electrons per Kilowatt-Hour:
   - A. "Standard Handbook for Electrical Engineers"
     The charge of an electron = 1.602×10^{-19} coulombs.
   - B. "Engineering Electronics"
     Charge of an electron = 1.60×10^{-19} coulombs.
   - C. Calculation of electrons per kilowatt-hour:
     One 100-watt lamp at 110 volts = 0.9 amp.
     A coulomb is one ampere for one second.

     $$\text{One coulomb} = \frac{1}{1.602 \times 10^{-19}} \text{ electrons}$$

     $= 6.24 \times 10^{18}$ electrons.
     One kilowatt-hour at 110 volts $= 0.9 \times 60 \times 60 \times 10$
     $= 32{,}400$ coulombs
     One kilowatt-hour $= 32{,}400 \times 6.24 \times 10^{18}$ electrons
     $= 202{,}176 \times 10^{18}$
     $= 202 \times 10^{23}$; or
     about 200×10^{23} electrons.

3. Calculation of "Weight" of a Kilowatt-Hour:
   One kilowatt-hour = 200×10^{23} electrons.
   One pound = 50×10^{28} electrons.

   $$\text{Therefore, one kilowatt-hour} = \frac{200 \times 10^{23}}{50 \times 10^{28}}$$

   $= 4 \times 10^{-7}$ lb.
   $= 0.0000004$ lb.

   $$= \frac{4}{10{,}000{,}000} \text{ lb.}$$

4. Retail Sale Price of a Kilowatt-Hour: Assume 4 cents per kilowatt-hour

$$\text{Cost per pound} = \frac{\$0.04 \times 10{,}000{,}000}{4}$$

$$= \$100{,}000 \text{ per lb.}$$

$$= \$200{,}000{,}000 \text{ per ton}$$

For other costs per kilowatt-hour, proportionate costs.

* 1,500–2,000 miles per second, the error being only 2% at 1/2th mile per second.

NOTE: In the early days of electric service, kilowatt-hours were sold by "weight." The electrochemical meters deposited metal on plates which were weighed. The energy used was calculated from these and billing was based on these figures.

Franklin's Priceless Gift

To the Editor:

True it is that out of his clarity of thought and power of simple exposition, Benjamin Franklin contributed to a better understanding of early electricity. But Mr. C. L. Jordan, in his article on "Benjamin Franklin's Priceless Gift to Electrical Engineering," in the January issue of *Electrical Engineering*, indulges in such fanciful hero-worship as to violate electrical history and require correction.

Franklin's book came out in a series of editions of different degrees of completeness, published in London in the 1750's and 60's by his friend who first attracted him to the subject, Peter Collinson. The book was a collection of Franklin's letters to Collinson reporting on his progress and ideas in experimenting with apparatus sent over by Collinson (and apparently by one of the Penns). He was guided by the considerable European literature on the subject then developing. Franklin had been drawn to the mysteries of electricity by the spectacular wave of advance that had preceded him, and which the present writer recently sketched in an article "The Electrical Flare of the 1740's," published in the May 1955 issue of *Electrical Engineering*.

Franklin's general position in the field is indicated by a contemporary scientist, he who translated into German, as of 1758, Franklin's letters, Prof. J. C. Wilcke. In his introduction, Wilcke praised Franklin for his explanation of the Leyden Jar (which proved to be wrong in respect to the role of the glass), but of Franklin's hypotheses generally he said: "The improving of the theory of Electricity, is an excellent piece of work . . . I say the improving of this theory. The system itself and the principles thereof which I shall outline briefly, are no discoveries of Mr. Franklin. One finds them already in other writings which were written before Franklin and of which we can assert according to Franklin's own words, that he read them. Mr. Watson and Mr. Elliot used them already in their treatises. . ."

With this bit of background, consider several of the claims made for Franklin by Mr. Jordan:

1. Franklin's book is said to have "become an important text in many American and European schools." This the present writer has been unable to verify. It seems doubtful in view of the nature of the book, a collection of letters, not intended as a text book.

2. Of the common words used by Franklin "probably for the first time" in connection with electricity: Several appeared in in the literature earlier: shock, charge, conductor, non-conductor, The most famous terms, "plus and minus," were an apt renaming of the earlier "surplus and deficite" conception of Nollet, and the still earlier, and more correct, interpretation of the opposite polarities of "vitreous and resinous" electricity, by Du Fay. Hence, Kettering's statement attributing to Franklin the first formulation of "the theory that electricity could exist in two states," is erroneous.

3. As to the list of similarities between electricity and lightning. given as if Franklin were the originator: They had been built up over the years as man learned how to produce more and more powerful discharges making the similarity more evident. They appear repeatedly in literature before Franklin; he was merely repeating them with some embellishment. For example, Prof. Winkler in his book of 1746 devotes a whole chapter (No. X) to these similarities. They convinced him that man-made electricity was miniature lightning. He speculated upon the generation of electricity in the clouds, as did Franklin in turn.

4. The electrical dinner described by Franklin is said by Mr. Jordan to have been "the spark which showed the way to our modern electric kitchens. . ." Actually, Franklin was joking, in good spirit(s)! His proposed dinner was a burlesque on the similar "stunts" of his European colleagues, and in recognition of his chagrin at having been able "to produce nothing in the way of use to Mankind." Useful electricity had to await the discovery of another kind, more amenable to control—the so-called Galvanic or Voltaic electricity, and the discovery of electro-magnetism, the dynamo, etc, etc. These came the following century, through such as Volta, Oersted, Ampere, Faraday, Ohm, Henry, whose names are forever engraved upon the standards of electricity as that science did produce "practical applications." Let not their credit be advanced to Franklin on this 250th anniversary of his birth; he has credit enough of his own. May *Electrical Engineering* keep electrical history objectively clear through all the anniversaries, is the prayer of this one more letter on Franklin!

Sincerely,

LLOYD ESPENSCHIED (AM '18, M '18, F '30)

(Bell Telephone Laboratories, Inc.)

First Transoceanic Telephone Cable

To the Editor:

The article appearing under the general departmental heading "Of Current Interest" on page 741 of the August 1955 issue of *Electrical Engineering* is of very great interest, and it is hoped and confidently expected that further bulletins recording the progress of this great undertaking will appear from time to time in the official publication of our Institute.

However, in view of the reputation of the magazine for a punctilious regard for accuracy, I feel it is only proper to point out that while a number of corporations and commissions are mentioned in connection with this undertaking, no mention at all is made of the great organization which is manufacturing and supplying almost the whole of the cable itself.

A later article has appeared in the November 1955 issue of the *Journal* of the Institution of Electrical Engineers (Great Britian). This article reports on the laying of the first long ocean section, and points out that the bulk of the cable had been made by a British firm whose forerunners had made the first submarine cable over 100 years ago.

Submarine Cables Limited, a corporation jointly owned by Messrs. Siemens Brothers & Company Ltd., and The Telegraph Construction & Maintenance Co. Ltd. of London, England, has been entrusted with the contract for the manufacture of 93% of the entire amount of submarine cable required for the project, and has actually produced ahead of schedule 83% of the first 1950 nautical mile link between Clarenville, Newfoundland, and Oban, Scotland, which was laid by *H.M.T.S. Monarch* in September 1955. Included in the 93% above mentioned is the 275 nautical mile link for the crossing of Cabot Strait between Terrenceville, Newfoundland, and Sydney Mines, Nova Scotia next year.

Contribution of Messrs. Submarine Cables Ltd. is valued at over 5 million pounds Sterling, and an entirely new factory was built and equipped at Erith in Kent in connection with the production of the transatlantic telephone cable.

Progress reports on great undertakings of this type are of very great interest and are eagerly read by all practicing electrical engineers. Therefore, if credits are to be given at all to individual corporations connected with such projects, it would seem well that these be kept in their proper perspective.

Very truly yours,

PHILIP J. CROFT (M '43)

(Canada Wire and Cable Company, Ltd.)

EDITOR'S NOTE. It is inferred in the item to which Mr. Croft refers that the cable laid from Newfoundland to Scotland was supplied by the Simplex Wire and Cable Company, whereas it was manufactured by the British concern.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

SILICIC SCIENCE. Ernst A. Hauser. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y., 1955. 188 pages, 9¼ by 6¼ inches, bound. $5. This monograph covers the composition and structure of siliceous compounds, ion-exchange reactions of silicate, ultra- and electron-microscopy of silicates and clays, the reaction of bentonite with organic compounds, and related subjects. Soil stabilization and silicones are treated in separate chapters, and the last chapter briefly reviews applications of silicic chemistry in ceramics, agriculture, drilling fluids, and in other fields. Chapter bibliographies are included.

STATIC AND DYNAMIC ELECTRON OPTICS. By P. A. Sturrock. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., 1955. 240 pages, 8¾ by 5½ inches, bound. $5.50. This monograph is

an account of the focusing of charged particles in static electromagnetic fields and in time-dependent electromagnetic fields as in particle accelerators. The author's aim has been to show the usefulness in these studies of certain concepts drawn from classical optics and dynamics; to develop procedures for the study of image-formation in electron-optical instruments and of stability in particle accelerators; and to apply these procedures to the analysis of electron lenses, mass spectrographs, cathode-ray-tube deflectors, and certain accelerators.

SWITCHING RELAY DESIGN. By R. L. Peek, Jr. and H. N. Wagar. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y., 1955. 478 pages, 9¼ by 6¼ inches, bound. $9.50. The account of the major relations controlling relay design which forms the first part of this book is suitable as an elementary text. Part two is a more detailed treatment of the subjects of part one and is intended as a reference book and design manual for relay engineers. The main topics covered include the mechanics of materials as related to spring design problems, the theory of vibrations as related to the motions of springs and relay members, and the performance relations of electromagnets.

TECHNICAL PUBLICATIONS. By C. Baker. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1955. 302 pages, 8¾ by 5½ inches, bound. $6. This is a guide specifically intended to aid engineers and other technicians in the preparation of engineering manuals, instructional leaflets, reports, and other types of technical publications. It deals with the selection of a style suited to the user, the use of clear language, methods of presentation, the use of illustrations, methods of reproduction, and preparation of copy for printing. Also briefly discussed are the use of technical literature in the aircraft industry, questionnaires, and specification writing.

TRANSISTOR ELECTRONICS. By Arthur W. Lo and others. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1955. 521 pages, 8½ by 6 inches, bound. $12. Emphasis in this book for advanced students and electronics engineers is on fundamental circuit aspects of the transistor and the physical principles governing transistor operation as a basis for practical circuit design. Proceeding from discussion of transistor physics and general properties of the transistor as a circuit element, the book takes up stabilization of the d-c operating point, low frequency amplifiers, high frequency operation, high-frequency amplifiers, oscillators, modulation, and pulse circuits. The effect of various physical phenomena of transistor action on equivalent circuits is also covered.

PROCEEDINGS OF THE AMERICAN POWER CONFERENCE. Volume XVII, 1955. Illinois Institute of Technology, Technology Center, Chicago 16, Ill., 1955. 722 pages, 9¼ by 6 inches, bound. $6. As in previous years the papers in these proceedings emphasize the practical rather than the theoretical view and range from the technical to the economic and social aspects of power generation, transmission, and distributions. Grouped by sessions—general interest, nuclear energy, mechanical, water technology, and electrical—the individual papers deal with such subjects as scientific manpower, sodium graphite reactor power plants, power plant stacks under wind loading, small gas turbines, the St. Lawrence Seaway, computing devices, and many others.

PROFESSIONAL ENGINEERS' INCOME AND SALARY SURVEY 1954–1955. National Society of Professional Engineers, 1121 Fifteenth Street, N. W., Washington 5, D. C. 43 pages, 9 by 6 inches, paper. $1. (N.S.P.E. members $0.50.) The information in this second biennial survey is based upon over 14,000 questionnaires returned by members of the Society. Data is given on the geographic distribution, type of employment, branch of engineering, and kind of work done by this group of engineers, and on the salaries they earned. The 1954 statistics are compared with the findings of 2 years previous.

QUANTUM THEORY OF SOLIDS. By R. E. Peierls. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y., 1955. 229 pages, 9¼ by 6¼ inches, bound. $4.80. An exposition of fundamental problems, addressed to theoretical physicists and to experimentalists with a working knowledge of quantum mechanics. The topics discussed include crystal lattices, cohesive forces in metals, ferromagnetism, semiconductors and luminescence, and superconductivity. A list of references is appended.

RADIO-TUBE VADE-MECUM, 1955. P. H. Brans, Ltd., Antwerp, Belgium, twelfth edition, 1955. 381 pages, 11 by 8 inches, paper. $5. Current normal operating data on tubes produced by the major manufacturers of the world are supplied in tabular form, with functions of the listed tubes indicated and base connections shown. A number of obsolete types have been omitted from this edition.

RESEARCH REACTORS. United States Atomic Energy Commission. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 442 pages, 10½ by 8 inches, bound. $6.50. This book gives descriptions of three types of light-water-moderated reactors (pool, solution, and materials-testing), and of three other types: hydro-carbon-moderated, heavy-water-moderated, and graphite-moderated. Information given for each type includes general design features, core design and fuel handling, cooling system (where applicable), control and instrumentation, shielding, experimental facilities, and operating characteristics. The book was prepared originally for the International Conference on Peaceful Uses of Atomic Energy.

SELEKTIVSCHUTZ. By H. Neugebauer. Springer-Verlag, Berlin, 1955. 261 pages, 9¼ by 6¼ inches, bound. DM 28.50. Intended for the power systems engineer and student, this book deals with the engineering fundamentals of electric system protection and their application. The latter half of the book on special protective relay systems describes the protection of the important components of a network: generators, transformers, line conductors. There is a bibliography.

POWDER METALLURGY. (Technical Assistance Mission No. 141.) Organization for European Economic Co-operation, Paris (U. S. agent- O.E.E.C. Mission, Suite 61, 2002 P Street, Washington 6, D.C.), 1955. 309 pages, 9½ by 6 inches, paper. $3. A report of a survey of the industry in the United States, made by representatives of seven European countries. The main body of the report deals with electrical and magnetic applications, hard metals, tungsten wire, cermets, engineering powders, the manufacture of structural parts, pressing processes, furnaces, standards, and quality control. Several pertinent specifications and a four-page bibliography are included.

ORIENTATION IN ENGINEERING. By Murray I. Mantell, Milton E. Reeder, and John A. Stevens. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1955. 85 pages, 10½ by 7½ inches, paper. $1.75. With the aim of helping students to adjust to college life, to clarify their ideas of the engineering college and profession, and to learn fundamental skills, this book considers such topics as classroom honesty, extra-curricular activities, studying, examinations, the use of libraries, the slide rule, and dimensional analysis. It also discusses the development of the engineering profession, engineering specialization, and the function of engineering education. Written assignments at the end of each section provide a basis for class discussion.

MOLECULAR BEAMS. By K. F. Smith. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1955. 133 pages, 6¾ by 4¼ inches, bound. $2. This small book is a study of the molecular beam technique used to make accurate measurements of the electrical and magnetic properties of atoms, molecules, and nuclei. It deals with methods of producing beams, their wave nature, magnetic and electric deflection of beams, and atomic and molecular beam radio-frequency spectroscopy.

MICROSCOPY OF CERAMICS AND CEMENTS. By Herbert Insley and Van Derck Fréchette. Academic Press, Inc., 125 East 23rd Street, New York 10, N. Y., 1955. 286 pages, 9¼ by 6 inches, bound. $7.50. The principal aim of this book is to review methods of microscopical examination and the interpretation of microscopical observations of whitewares, refractories, glass, cements, porcelain enamels, structural clay products, abrasives, foundry slags, and metallurgical slags. Features and techniques of use of the polarizing and other types of microscopes, fundamentals of optical mineralogy, and microscopic characteristics of the raw materials of ceramics are discussed as background material for the treatment of specific problems in the various fields.

METALS HANDBOOK. 1955 Supplement. Edited by Taylor Lyman. American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio, 1955. 208 pages, 11 by 8½ inches, bound. $6. The second in a series of supplements issued in order to make important material available sooner than would be the case if it were held until the revision of the 1948 Metals Handbook is completed. Various aspects of materials and applications, design, processing, fabricating, testing, and inspection are dealt with in articles which are either entirely new or are revised treatments of subjects previously covered.

LINEAR FEEDBACK ANALYSIS. By J. G. Thomtason. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 365 pages, 8½ by 5½ inches, bound. $8.50. Intended to provide the analytical background for work in electronics or servomechanism research, this book covers modern network analysis methods, feedback concepts, tube amplifying characteristics and, in considerable detail, stability in negative feedback systems. Three chapters are devoted to illustrative descriptions of amplifier, integrator, differentiator, and stabilized power unit circuits.

LEGAL CASES FOR CONTRACTORS, ARCHITECTS, AND ENGINEERS. By I. Vernon Werbin. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 487 pages, 8½ by 5½ inches, bound. $6. The author, a licensed professional engineer as well as a practicing attorney, discusses 52 situations which have actually arisen out of construction contracts. Among the problems covered are contracts required to be in writing; liability for defective work; damages resulting from erroneous location of work by an engineer; damages recoverable by owner for defective construction, etc. Each discussion is accompanied by citations of appropriate cases.

INTRODUCTION TO ELECTRONIC ANALOGUE COMPUTERS. By C. A. A. Wass. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 237 pages, 8½ by 5¾ inches, bound. $6.50. This is a discussion of recent developments in machines and techniques, with emphasis on principles rather than on detailed designs and design methods. Principles of differential analyzers and simulators are demonstrated by the solution of typical linear and non-linear problems, and extended treatment is given to computer components. One chapter is devoted to descriptions of some existing computers, such as the "Gepus" and "Tridac."

FUNDAMENTALS OF TELEVISION ENGINEERING. By Glenn M. Glasford. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 642 pages, 9¼ by 6¼ inches, bound. $9.50. The emphasis in this book is on systems concepts, their implementation in circuits and their analysis. Low-level circuits and random noise problems are treated in detail, and considerable space is devoted to equivalent circuits, the functions of vacuum tubes, synchronizing, and the Laplace transform method of transient analysis. The treatment of color television is integrated with appropriately related material.

FUNDAMENTAL FORMULAS OF PHYSICS. Edited by Donald H. Mansel. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y., 1955. 765 pages, 8½ by 5¾ inches, bound. $13.50. These formulas, sometimes merely listed, sometimes accompanied by explanatory material, are grouped in 31 chapters devoted to basic mathematics, statistics, nomograms, physical constants, and to various special fields such as hydrodynamics, kinetic theory of gases, electromagnetic theory, sound, nuclear theory, and the solid-state. Certain related fields in chemistry, astronomy, meteorology, biology, and electronics are also covered. Many of the chapters; for example, the one on electromagnetic theory, have been designed to meet the needs of engineers as well as physicists.

ELECTRONIC TRANSFORMERS AND CIRCUITS. By Reuben Lee. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1955. 360 pages, 9¼ by 6 inches, bound. $7.50. The design of transformers and the effect of their characteristics on circuits are dealt with using a minimum of mathematics and stressing physical concepts. As in the previous edition, the arrangement of material is, for the most part, by general types of apparatus with design data for a particular transformer presented in connection with the purpose for which it is intended. Some sections have been deleted from this edition, some sections have been expanded, and new chapters on magnetic amplifiers and pulse circuits have been added.

ELECTRONIC AND RADIO ENGINEERING. By Frederick Emmons Terman. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., fourth edition, 1955. 1,078 pages, 9½ by 6 inches, bound. $12.50. The change of title in this edition from the title, "Radio Engineering," of the previous editions reflects the greater emphasis on general techniques of electronics without regard to their use in radio sys-

ems. In manner of presentation and coverage, the book remains the same: a summary in readily understandable terms of basic principles and techniques treated in three parts devoted to circuit elements and circuit theory, radio engineering and radio systems, and electronic fundamentals. Some material has been added to most of the chapters, and the chapters on microwave tubes and transistors are new.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Preferred Standards for the Presentation of Frequency Response Data. (ASME Standard 107.) The method of presenting frequency response information given in these standards applies not only to the entire field of automatic control but to all physical systems when interest is in the relation between the outputs and inputs of these systems. 8 pages. $1 per copy. Order from the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

American Standard Small Solid Rivets, ASA B18.1-1955. ASA Sectional Committee B-18 was organized under the procedure of the American Standards Association, with the American Society of Mechanical Engineers and the Society of Automotive Engineers as joint sponsors. Subcommittee No. 1 was appointed to standardize rivets. The proposals of this Subcommittee were approved and designated as American Standard on October 5, 1955. 15 pages. $1 each. Send order to the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

Automation and Job Trends. This pamphlet is a study by the Council for Technological Advancement and states that dynamic flow of labor from one industry to another is essential if the full benefits of automation are to be realized. It is not desirable to seek to maintain a status quo in employment in any particular industry or segment of the economy as flexibility is essential. The progress of the past could never have been achieved if millions of Americans had not shifted from farming and mining to manufacturing, trade, and service occupations. Those remaining in an occupation have larger incomes because each now produces more, thanks to technology. The advance of automation technology will depend on the availability of risk capital and special technical skills needed to design, build, maintain and operate new types of equipment. 24 pages. Single copies, free. Additional copies 25¢ each. Quantity prices on request. Available from Council for Technological Advancement, 120 S. La Salle Street, Chicago 3, Ill.

Farmstead Wiring Handbook. New, upgraded wiring standards for America's farms are set forth in the revised edition of this guide. Published by the Industry Committee on Interior Wiring Design, the new manual supersedes an original edition issued in 1946. Made necessary by the farmer's rapidly expanding use of electrical farm production equipment, the new edition is a sequel to the committee's "Residential Wiring Handbook" published last year. The handbook is divided into three sections: Interior wiring design, outdoor electrical distribution, and a series of tables which show wire sizes needed to carry various electric loads. All are explained in easily understood text and diagrams. The manual is designed for use by agricultural colleges, electric power suppliers, architects, engineers, builders, electrical contractors, and lending institutions, as well as the farmer. 48 pages. 50¢. Quantity prices on request. From Industry Committee on Interior Wiring Design, Room 2650, 420 Lexington Avenue, New York 17, N. Y.

Architectural Engineering. Today there seems to be no limit to the engineering possibilities in buildings, whether of height and span of structure, indoor climate, or any of the other aspects of building technology. This book is a source of information on new concepts, materials, and applications for everyone concerned with building design and construction. There are 98 profusely illustrated articles, all written by technical experts, covering a variety of building types. Each study is graphically complete with plans, diagrams, structural details, and photographs—over 1,400 in all. There are six sections on the Building Shell, Environmental Control, Utilities, Site Planning, Materials, and Special Problems. Of special interest are explorations into new areas such as heat pumps, solar heating, thin-shell structures, lightweight aggregates, structural plywood, and atomic blast-resistant buildings. 494 pages. $11.50. Send order to: F. W. Dodge Corporation, 119 West 40th Street, New York 18, N. Y.

American Standard Safety Code for Elevators. This revised code of safety standards covers the design, construction, installation, inspection, testing, maintenance, alteration and repair of elevators, dumbwaiters, escalators, private residence elevators, and inclined lifts and their hoistways. The code is intended to serve as a guide for state and municipal authorities in drafting regulations governing the installation and maintenance of elevators, dumbwaiters, and escalators. It is also intended as a standard reference of safety requirements for the guidance of architects, engineers, casualty insurance companies, manufacturers, and for owners and managers of structures where equipment under the scope of this code is used. 290 pages. $3.50 for paper-bound edition and $4 for cloth-bound edition. Copies may be obtained from The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

Catalogues of Government Technical Reports. Two catalogues of technical reports available from the Government, one on electroplating and polishing and the other on photochemistry and photoelectricity, have been compiled, by the Office of Technical Services (OTS), U. S. Department of Commerce. These documents are primarily reports of research done under Government sponsorship by either Government or private laboratories, but some of the documents are technical papers captured by the Allies in Germany in World War II. 10¢ each. Send order for CTR-159 Electroplating and Polishing and CTR-311 Photochemistry and Photoelectricity (Excluding Photography), to the U. S. Department of Commerce, OTS or the Library of Congress, Washington 25, D. C.

Effects of an Atomic Blast on Electric Power Facilities. A detailed report by the men who carried out last spring's "Operation Cue" test has been published by the Edison Electric Institute (EEI). The test was made last May at the Atomic Energy Commission's atomic test site in Nevada where the Edison Electric Institute, representing the electric power industry, joined with other industries and the Federal Government to find out what would happen to a community under nuclear attack. Two identical electric transmission and distribution systems were constructed. Both were placed in the so-called "Survival City" test area where houses, radio towers, industrial machinery, gas utility equipment, and other test items were located. To determine their approximate survival range, one system was built 4,700 feet from "ground zero," the point of explosion, while the other was at 10,500 feet. Each system included a 69-kv line installed on one steel suspension tower and one steel dead-end tower; the substation equipment consisted of a 69-kv oil circuit breaker, and step-down transformers and associated structures. The distribution substation equipment consisting of two 4-kv oil circuit breakers and voltage regulators and about a half-mile of 11-kv and 4-kv distribution lines construction on wood poles, with distribution transformers and secondaries. Less than 3 hours after the blast (equivalent to 30 to 35 kilotons of dynamite) EEI project members moved into the stricken area to make a detailed report of their observations. 75¢ each. Copies of the report are available from Edison Electric Institute, 420 Lexington Avenue, New York 17, N. Y.

So You Want To Be a Ham. In 12 well-defined, illustrated chapters the prospective "ham" will find what he needs to know about getting his license and his equipment. 196 pp. $2.50. This catalogue, *HAM-1* may be obtained by writing Howard W. Sams and Company, 2201 East 46th Street, Indianapolis 5, Ind.

American Society for Testing Materials Reference Radiographs. Work of the American Society for Testing Materials (ASTM) Committee E-7 on Non-Destructive Testing has resulted in the preparation of reference radiographs covering types and degrees of discontinuities in steel welds. The reference radiographs are reproduced from master radiographs taken of official sample weld plates which are the property of ASTM. The radiographs, in the form of transparencies, are mounted in standard 5- by 8-inch Keysort cards. Details of plate thickness, radiographic method, and welding procedures are given on each card. The transparencies, although reproduced to a density level of approximately 1.0, retain the original radiographic contrast. The complete file of 35 radiographic transparencies can be purchased from the American Society for Testing Materials Headquarters, 1916 Race Street, Philadelphia 3, Pa.

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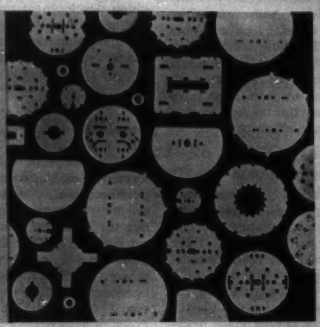

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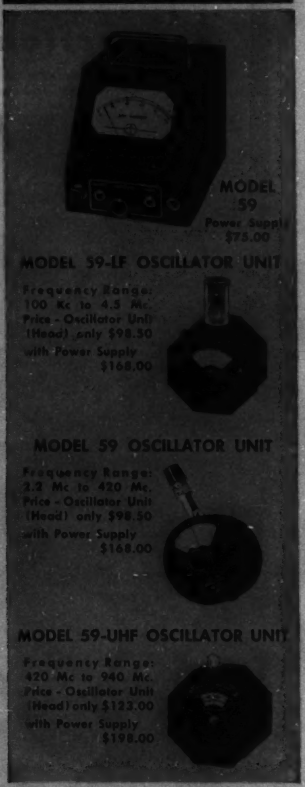
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Power Supply $75.00
MODEL 59-LF OSCILLATOR UNIT
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Measurements' Megacycle Meter is now available in a choice of three oscillator heads providing frequency range coverage from 100 Kc to 940,000 Kc. Thus, the utility of this versatile instrument has been extended, making it, more than ever, indispensable to anyone engaged in electronic work; engineer, serviceman, amateur or experimenter.

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INDUSTRIAL NOTES ...

Electron Tube Information Service. The National Bureau of Standards (NBS) has established a tube information service for accumulating and disseminating technical data on both domestic and foreign manufactured radio tubes. At the present time, nearly 10,000 cards, filed by tube type number, are appropriately referenced to manufacturers' source material. In addition, about 10 per cent of these cards, selected mainly from the high-use miniature and subminiature types, have been coded on punched cards for mechanical sorting. With this service, it is possible to find: information about any particular tube; all tube types whose electrical characteristics, bulb sizes, or base configurations fall within particular ranges; and domestic tubes that can be substituted for unavailable foreign-make tubes. Recently, junction diodes and transistors have been added to the Bureau's program, which began about seven years ago as a service to NBS personnel. It has since been extended to all scientists and engineers in Government and industry who have legitimate requests. This continuing service is being carried out by C. P. Marsden, and J. M. Moffitt of the Bureau's electron tube laboratory. Inquiries should contain as much factual information as possible to expedite the reference research, and should include background information where appropriate. The service cannot undertake to answer queries on tube applications in circuits; complex or highly detailed questions that may require laboratory research can be answered only on the basis of data available. Address inquiries to C. P. Marsden, Chief, Electron Tubes Section, National Bureau of Standards, Washington 25, D. C. Manufacturers are urged to supply the Bureau with technical information on new tube types as they are placed on the market, so that the service can include all the most recent data.

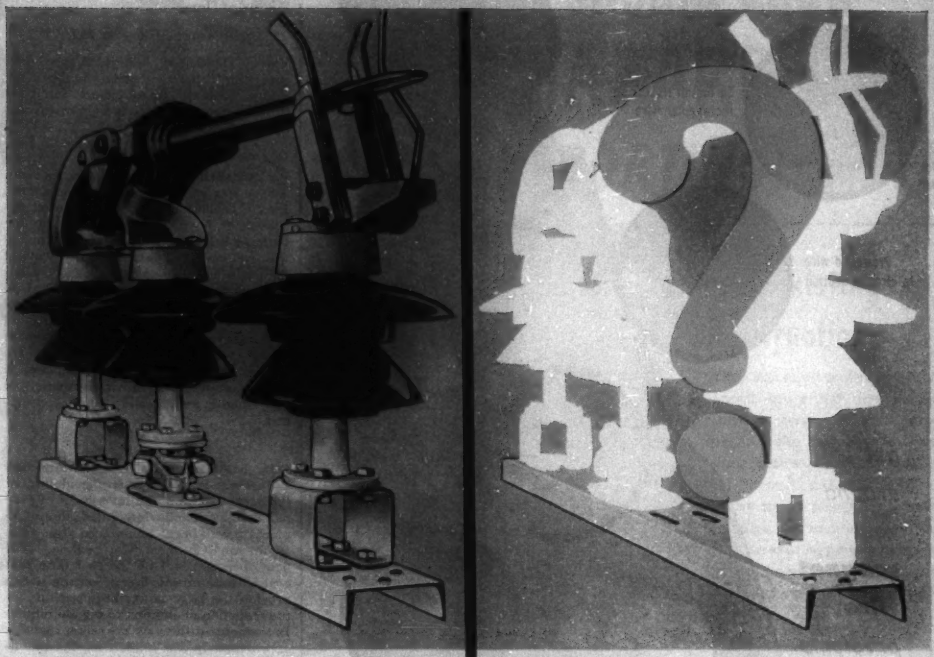
New Bonding Process. An important advance in copper clad laminates for printed circuits is a bonding process developed by National Vulcanized Fibre Company, which results in faster production, and fewer rejects. The process is being adopted for various grades of the company's phenolite laminated plastics to form a new line of copper clads designated as the *HP* series. These copper clads possess double bond strength, 12 to 15 pounds, and a much higher dip solder temperature resistance (30 seconds at 500 F). Productionwise, the new *HP* series speeds operation, provides cleaner soldered joints, and minimizes bridging in the printed circuit. The process includes a new method for uniformly conditioning the bonding surface of either electrolytic or rolled copper foil. Combined with this is the use of a stronger adhesive for bonding the treated copper surface to the laminate. Both are the result of original research conducted by Houghton Laboratories, Inc., for the Army Signal Corps at Forth Monmouth, N. J. Additional information is available from National Vulcanized Fibre Company, 1055 Beech Street, Wilmington, Del., or National Fibre Company of Canada, Ltd., 107 Atlantic Avenue, Toronto, Ont., Canada.

Proctor Elected Head of AICE. The American Institute of Consulting Engineers (AICE) has announced the election of C. S. Proctor, New York, N. Y., as president, succeeding F. S. Friel, of Philadelphia, Pa. Col. Proctor, former president of the American Society of Civil Engineers and a trustee of Princeton University, is a partner in Moran, Proctor, Mueser and Rutledge. Others elected are Richard Hazen and Robert W. Abbett, both of New York, N. Y.—vice-president; Herschel H. Allen, Baltimore, Md.; Ellis E. Paul, New York, and Maurice R. Scharff, New York—members of the Governing Council.

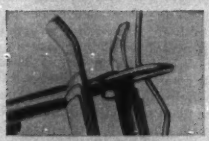
New Engineering and Sales Building. The Kearfott Company, Inc., has announced plans for a new engineering-sales building to be constructed opposite its present location in Little Falls, N. J. The building will centralize offices, laboratories, pilot plants, and other Kearfott engineering departments, providing the latest in laboratory facilities for the precision development projects carried on by the firm. Newly leased space in Clifton, N. J., is being used as an interim facility to relieve crowded quarters in the company's present engineering plants.

Atomic Research Construction Project. The Power Reactor Development Company, a nonprofit corporation, has been formed to design, construct, and operate a developmental fast-neutron breeder reactor. The new organization will carry out the atomic reactor power plant project initiated by The Detroit Edison Company and a number of other electric power, manufacturing, and engineering concerns including the Babcock and Wilcox Company. This project was proposed in March 1955 as part of the United States Atomic Energy Commission's (AEC) Power Demonstration Reactor Program. The AEC announced on August 8, that the proposal provided an acceptable basis for negotiations under that program. The new company was organized to consolidate the efforts of those having an interest in breeder reactor development. Most of the companies now involved in the proposed construction project have been engaged in atomic power plant research and development for five years or more. Babcock and Wilcox formed an Atomic

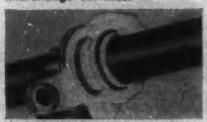
(*Continued on page 20A*)



Original or 'similar'— which do you prefer?



Delta-Star MK-40 Switches feature maximum contact efficiency and safety, with minimum current interchange surfaces.



Blade mechanism of MK-40 Switches has only three moving parts, yet develops enormous rotating operating leverage.

When you consider high voltage switches, one stands out because of its original performance-proved features that seem to be appearing in other switches. The standout is Delta-Star's MK-40.

Appearance to the contrary, *Delta-Star MK-40 Switches alone offer a combination of unequalled advantages originated by Delta-Star.* They feature sturdiest possible construction and large, rugged sealed-type ball bearing blade actuating mechanism for assured long service. They have a minimum number of moving parts and minimum current interchange surfaces—for efficiency and ease of operation. Contact pressure-applying springs carry no current, and offer large deflection to maintain uniform high pressure contact over extended periods of use. The fully controlled blade makes high pressure silver-to-copper contacts at both ends. Contacts are fully visible for inspection.

Similarities help prove the exceptional value of the original. That certainly applies to Delta-Star MK-40 Switches—in all ratings—400 to 5000 amperes and 7.5 to 380 kv. Keep the MK-40 as your standard of comparison.

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To install HYLUG on rectangular wire
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MAGNECRIMP METHOD

for pre-rounding magnet wire to fit STANDARD lugs

Until now, terminals have been trouble spots in magnet wire conduction. Now, the new Burndy Magnecrimp method provides inexpensive compression terminations of maximum conductivity and mechanical strength . . . and resistant to corrosion and vibration, too.

"Magnecrimping" pre-rounds square or rectangular magnet wire to the proper size for standard Burndy Hylugs. A compound die for sizes up to 1/0 round re-shapes conductors singly or in combinations. Wire and Hylug form a tight joint. No wasted metal from oversized lugs.

The pre-formed wires in the Hylug are then compression-connected with a standard Burndy quadrangular crimp. Rounding and compression work-hardens the copper wire, strengthening the joint up to 90% of rated breaking strength of conductor.

For more detailed information, send for Burndy Bulletin MAG 55.
For recommended die sets and terminals, write:

BURNDY 56-6

Norwalk, Connect. • Toronto, Canada • Other Factories: New York, Calif., Toronto • Export: Philips Export Corp.

Industrial Notes

(*Continued from page 18A*)

Energy Division in April 1953 to consolidate the firm's activities in the field. Power Reactor Development Company will represent the interests of 26 companies involved.

Packard-Bell Buys Printed Circuit Firm. The assets of Technical Reproductions, Inc., a California firm in the printed circuit field, have been purchased by the Packard-Bell Company. The company will be operated as a department of Packard-Bell's Technical Products Division, under the direction of Richard B. Leng, vice-president in charge of the division. The employment of printed circuits, an electrical etching process of wiring whereby circuit conductors are formed upon an insulated baseplate, is an advanced development involving the use of plastic materials in electronic equipment.

Olin Mathieson To Enter Aluminum Industry. Plans to enter the aluminum industry with an initial investment of $120 million and a fully integrated aluminum plant have been announced by Olin Mathieson Chemical Corporation. The new operation will be the first time that coal is to be mined directly on the site to provide the large power requirements for the reduction of alumina to pig aluminum. Investment in the new operation includes approximately $90 million for the aluminum plant and $30 million for the power facilities needed for the aluminum plant. The new facilities will be located in the Ohio River Valley. The alumina plant, the reduction plant, and the rolling mill will be on the Ohio River near Clarington, Ohio. The power plant to be engineered and built by American Gas and Electric Company will be slightly upstream on the West Virginia side at Cresap Bottom and will be connected to the aluminum facilities by a high-tension transmission line. The power plant will be built on a new major coal mine which will be constructed, owned, and operated by the Pittsburgh Consolidation Coal Company. The power plant, known as the Kammer Plant, will consist of two units of 225,000 kw each. One unit will be owned by the Ohio Power Company, a subsidiary of the American Gas and Electric Company; the other by a joint subsidiary of Olin Mathieson Chemical Corporation and Pittsburgh Consolidation Coal Company. Both power units will be operated by the Ohio Power Company and integrated into the American Gas and Electric Company System. The plant will be designed for development up to 1.35 million kw capacity.

Selenium Wanted. High-purity selenium is now so scarce that the Federal Telephone and Radio Company, division of the International Telephone and Telegraph Corporation, is conducting a campaign to reclaim this scarce material needed for radio, television, and power rectifiers. Selenium

(*Continued on page 26A*)

what you should know about HAZARD SELF-SUPPORTING CABLE

installation costs are low

. . . surprisingly low. In many cases, far less than for open wire construction. Installation costs are low because the cable is easy to work, splice and terminate. Maintenance and tree trimming costs are greatly reduced.

uses existing construction

When you need power in a hurry —can't spare the time or expense to buy conduit or erect special poles and towers—your wisest choice would be Hazard Self-Supporting Aerial Cable. It can be strung along the sides of buildings, under bridges or viaducts, on existing poles and towers or on almost any structure between power source and point of use.

safe against the elements

Hazard Self-Supporting Aerial Cable is widely used for its ability to resist the effects of moisture, heat, abrasion, cold and corrosive industrial atmosphere. Add to this its installation versatility, and you will quickly see why it is becoming an increasingly popular system of power distribution.

safe in congested areas

As in this modern textile plant where 12 power circuits are included in one compact installation, Hazard Self-Supporting Aerial Cable can be run easily and safely in "congested areas" like narrow passageways between buildings, where trees are a problem, where the aerial approach is already crowded or on poles and towers too full for another bare circuit. With its superior insulation, flashovers and danger to personnel and property are effectively minimized.

Complete information on Hazard Self-Supporting Aerial Cable is available in the free Bulletin H-464. Hazard Division of The Okonite Company, Passaic, N. J.

3651

HAZARD INSULATED CABLES

PRODUCT OF OKONITE RESEARCH

First there's the 120 Wirewound TRIMPOT, with features common to all other BOURNS TRIMPOTS. It's a 25-turn potentiometer, easily adjusted, and weighing only 0.1 oz. Rectangular in shape, it fits readily into miniature electronic circuits. You can mount it individually, or stack it compactly with standard screws. Mountings are interchangeable with those on all other TRIMPOTS.

The self-locking shaft holds stable settings under extreme environmental conditions. All parts are corrosion resistant. Every unit is inspected 100% for guaranteed specifications. Resistances: 10 to 20,000 ohms, with resolutions as low as 0.2%.

Now, to give designers greater latitude, BOURNS has developed and is manufacturing the following standard models—variations of the Model 120.

120 TRIMPOT
—Carbon
Infinite resolution is provided by the carbon element. Resistances are higher, ranging from 20,000 ohms to 1 megohm.

130 TRIMPOT
—Solder Lug
For wiring direct to the instrument, using soldering iron or dip soldering techniques. Usable range of 98%.

132 TRIMR
—Variable Resistor
High resistances—up to 50,000 ohms in a wirewound rheostat.

209 TWINPOT
—Dual Potentiometer
Two outputs electrically independent, and controlled simultaneously by one adjustment.

160 TRIMPOT
—High Temperature
Operates at 175°C. High power rating: 0.6 watt at 50°C.

230 TRIMPOT
—Humidity-proof
Completely sealed, unit meets MIL-E-5272A Specifications for humidity.

Write for literature on the BOURNS TRIMPOT line.

BOURNS LABORATORIES
General Offices: 6135 Magnolia Ave., Riverside, Calif.
Plants: Riverside, California—Ames, Iowa

Industrial Notes

(Continued from page 20A)

is a by-product of copper-smelting processes, and the rapidly expanding use of selenium in power rectifiers, plus copper-mining work-stoppages in the past year have placed a great strain on sources of supply. Acting on a recommendation made by the Business and Defense Services Administration of the United States Department of Commerce, Federal is taking steps to assure the continued availability of high-purity selenium by paying its customers for every used selenium rectifier which is returned for salvage, and is widely advertising to its customers the need for success in this effort.

Pennsylvania Transformer Makes Gift to Wildlife Foundation. Pennsylvania Transformer Company, Canonsburg, Pa. made a gift of dam and water reservoir sites totaling nearly 125 acres to the North American Wildlife Foundation, which has stated that the property will be developed "in the public interest." The property, which straddles Peters and North Strabane Townships a few miles northeast of Canonsburg, is valued at approximately three quarters of a million dollars.

Building Program Announced. A $5 million building program which will give Armour Research Foundation of Illinois Institute of Technology a complete industrial research center has been planned. The expansion program calls for the construction of 3 buildings and substantial additions to 2 buildings over the next 10 years. The building plans are based on the assumption that the Foundation will have a research volume of $16 million and a staff of 1,600 by 1961.

New Company Organized. Claude L. Matthews has organized and assumed presidency of the Matthews Engineering Corporation. In the North Central States, this corporation will represent the Gates Engineering Company of Wilmington, Del., manufacturers of liquid neoprene and vinyl products. Offices of the newly formed company are located at 3545 Lindell Boulevard, St. Louis 3, Mo.

ALCO Facility To Be Built. Plans for construction of a reactor criticality facility at Schenectady, N. Y., has been announced by ALCO Products, Inc. To be built and equipped at a cost of about $230,000, the nuclear laboratory is expected to be completed in May 1956. It will be located on the Mohawk River, N. Y., in the company's main plant. The reactor facility will be used for nuclear experiments in connection with ALCO's contract for design and construction of the Army Package Power Reactor.

Sprague-Philco Agreement. The Sprague Electric Company, will start production this year of a type of transistor

(Continued on page 30A)

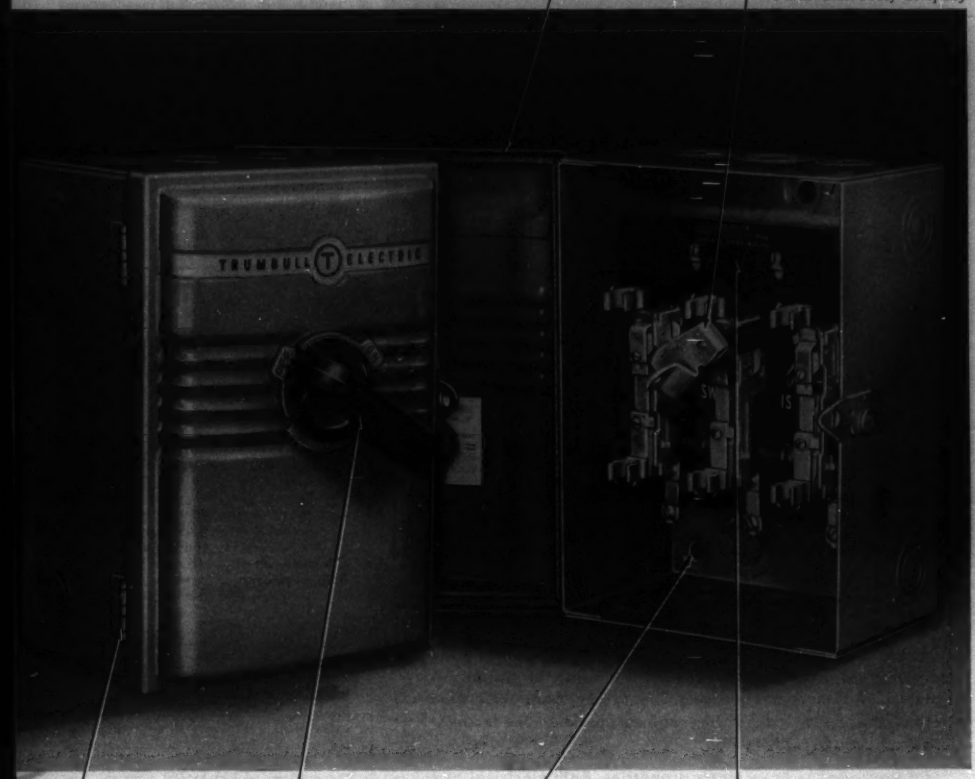
HERE ARE EXTRA VALUES G-E HEAVY DUTY HCI SWITCHES GIVE YOU

Successfully operates with 100,000-amp interrupting capacity fuses. Test data available. Built for rugged operation under severe conditions.

NEMA 1A enclosure with rubber gasket is standard. Semi-dust tight for use in dust-laden atmospheres. Bonderite* treated for corrosion resistance.

Door interlocked. When handle is padlocked either ON or OFF, door cannot be opened. If desired, up to three padlocks can be used.

*Parker Rust Proof Company



Piano hinges on door. More rigid, more durable. A G-E safety measure. Heavy steel box takes plenty of abuse.

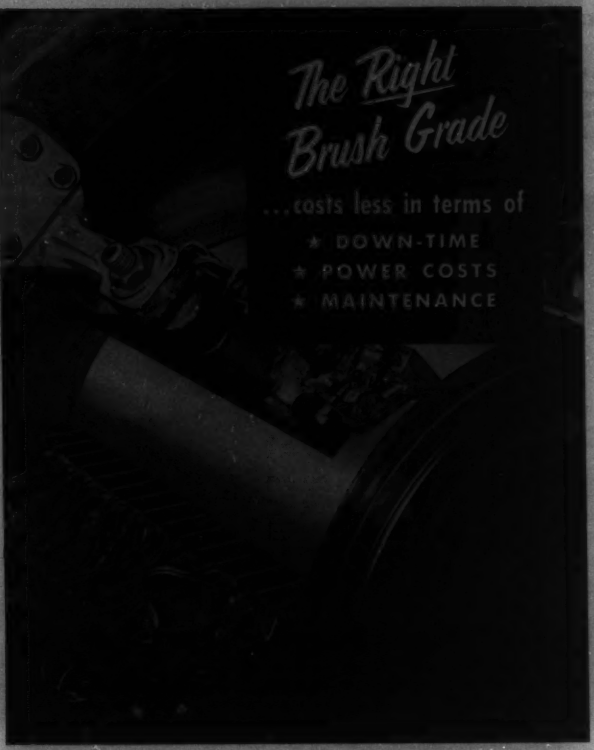
Front-operated die-cast aluminum handle. Strong, unbreakable, easy to grip. Makes close ganging easy.

New "Tripod Mounting" permits firm installation on irregular walls. Rough handling won't shake box loose.

Line Shield guards against accidental contact. No live parts are exposed when switch is off and door open.

G-E's heavy duty HCI switches are sturdily constructed to withstand severe electrical and mechanical stresses. Available in ratings from 30 to 200 amps, 125 to 600 V AC and 240 V DC in two- or three-pole construction. For quick delivery call your G-E Trumbull Distributor. For switchboard and industrial control applications HCI disconnects are easy to mount, have many cost-saving features.

GENERAL ELECTRIC



To the engineer who hopes to obtain economy in operation, economy of effort, and freedom from anxiety, selecting the *right* brush grade for a specific job is a matter of real importance. And sometimes, puzzling. That is why Morganite is glad to offer him the services of its engineers to determine the most suitable grade for his purpose.

Carbon brushes have many properties. Both electrical and physical. All should be considered carefully. Many times those features in a brush which are of fundamental importance in one installation may be of little or no importance in another, where other features may demand special attention.

Up-to-date and complete information on all Morganite classes and grades of brushes is now available in a new Brush Catalogue — just off the press. Write for your copy today.

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Manufacturers of fine carbon-graphite products for fifty years.
3308 48th Avenue, Long Island City 1, New York

Industrial Notes

(*Continued from page 26A*)

developed by the Philco Corporation. An agreement was executed between Sprague and Philco under which Sprague is licensed to produce the Philco surface-barrier transistor. Importance of the Sprague-Philco agreement in the electronic world lies in the fact that it will provide two independent manufacturing sources for an identical high-frequency transistor. Under the agreement, both firms are privileged to exchange research and development data as well as production and testing techniques on devices in the entire field of semiconductors.

Mexican Subsidiary of Sylvania Formed. The formation of Semsa Electronica, S.A., a manufacturing subsidiary of Sylvania Electric Products Inc., has been announced. The new company now is building a 40,000-square-foot plant in Monterrey, Mexico, where television sets and television picture tubes will be produced. This organization is the result of the rapid expansion of television in Mexico. Semsa is scheduled to begin the manufacture of aluminized black-and-white picture tubes in early March, and by mid-year is expected to be in production of television sets. Both products will bear the Sylvania trade name.

Transistors Used in Automobile Radio. A major advance in the automotive radio field was revealed by the Delco Radio Division of General Motors, with the introduction of an automobile radio which includes transistors. The new radio will be available on a production car in the Chevrolet Corvette.

NEW PRODUCTS

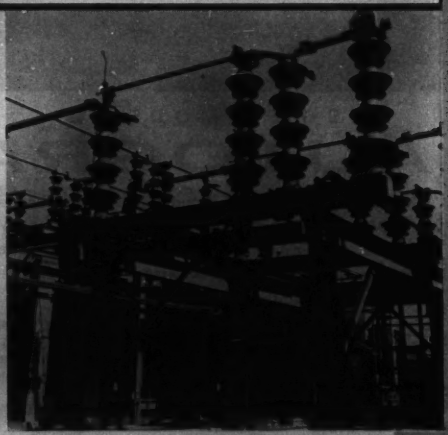
High Resistance Megohmmeter Incorporates New Features. A new megohmmeter with ranges to 50-million megohms (5×10^{13} ohms) and continuously variable test voltages of 100 to 600 volts d-c has been announced by Industrial Instruments, Inc., Cedar Grove, N. J. The model *L-7* megohmmeter incorporates features for greater operational ease, accuracy, and safety. It is ideal for testing voltage coefficients of the newer insulating materials as the infinite number of test voltages between 100 and 600 volts may be used to evaulate characteristics at several settings. In capacitor testing, the model *L-7* provides charge and discharge facilities to eliminate meter slam. Test voltages are read on the meter scale by means of a front-panel switch. Provision for calibrating the megohm scale for each new voltage setting eliminates the need for conversion factors and provides direct scale readings for every voltage. A unique indicating meter with logarithmic response

(*Continued on page 32A*)

FROM SEATTLE TO NEW YORK IT'S THE TYPE wag SWITCH!

Southern States' switches being specified by more and more utilities

SEATTLE—City of Seattle, Department of Lighting, uses 44 Type WAG Switches with AMPLITACT® in its new Duwamish Substation, seen here, and 12 in its Shoreline Substation.



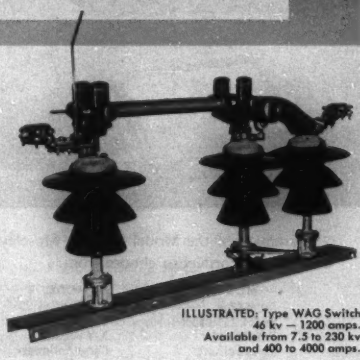
NEW YORK—Consolidated Edison Company's Astoria Generating Station uses Southern States 161 kv 1200 amp Type WAG Air Break Switches and G-WAG Grounding Switches.

Here is why growing numbers of Southern States' Type WAG Switches are being used throughout the nation:

Increasing generating capacities, with higher degrees of integration and corresponding increases in short circuit capacities, require switches that will meet these conditions.

The Type WAG carries its rated current indefinitely without excessive temperature rise and withstands high short circuits without damage. Even under the most adverse conditions, such as icing, the Type WAG can be depended upon to perform adequately.

All of the features are described in Bulletin 390-R. Get a copy from your Southern States representative, or write direct, and see why it will pay you to specify and use Type WAG Switches.



ILLUSTRATED: Type WAG Switch 46 kv — 1200 amps. Available from 7.5 to 230 kv and 400 to 4000 amps.

SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

THE NEW MODEL 3

AUTOGRAF

trade mark

The Model 3 AUTOGRAF X-Y Recorder incorporates the proven features of the Model 2 in a compact instrument, ideal for use with standard 8½" x 11" graph paper. Rugged, accurate, fast, and stable, the Model 3 provides facilities for curve drawing and curve following with full visibility of the recording while in operation.

- Ranges: 5 mv up to 500 volts, full scale.
- Independent, isolated inputs, free of ground.
- Speeds: Up to ½ second, full scale.
- Resolution 0.1%; accuracy and resolution 0.25%.
- 200,000 ohms/volt input resistance.
- Zero set and one full scale length zero offset, both axes.
- Liquid ink or ball point pens.

The addition of the Model 3 to the Moseley AUTOGRAF line gives you three X-Y recorders to choose from:

MODEL 1	MODEL 2	MODEL 3
Drum type	Flat-bed	Desk Type
8½" x 11" paper	11" x 16½" paper	8½" x 11" paper
X-Y Recorder-	X-Y Recorder-	X-Y Recorder-
Curve Follower	Curve Follower-	Curve Follower
	Point Plotter	

More than 1000 AUTOGRAFS are in use in laboratories, universities, and industrial plants throughout the U. S. and overseas.

F. L. MOSELEY CO.

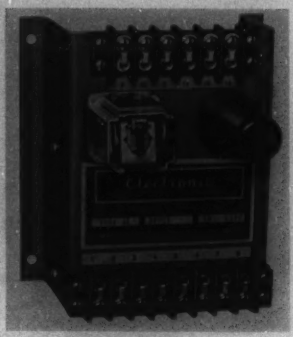
Bulletins describing these instruments are available and we'll be glad to send them to you.

New Products

(*Continued from page 30A*)

provides uncrowded, easy-to-read, high-end scale. The *L-7* utilizes 115 volt, 50/60 cycle power line as power source.

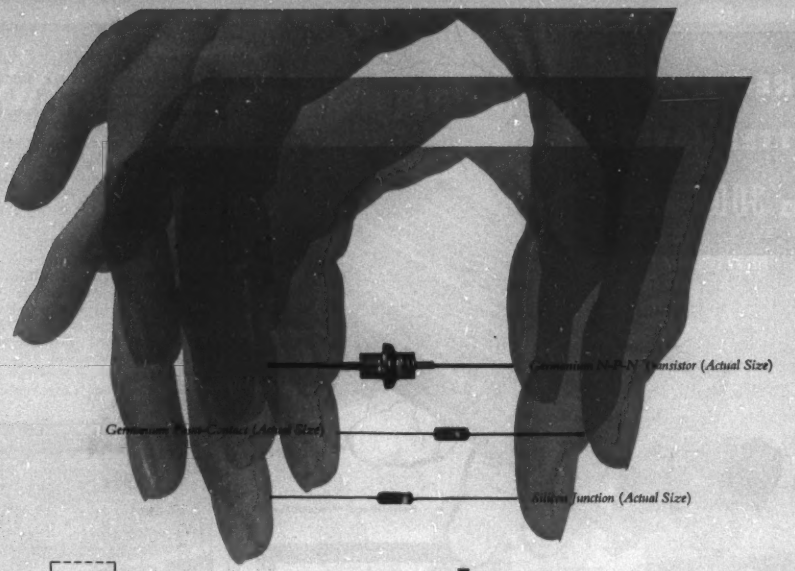
Electronic Liquid Level Control. Machinery Electrification, Inc., of Northboro, Mass., has announced the development of the *MEK-3001A* electronic liquid level control for general processing industries. The *MEK-3001A* was designed to provide a device which will minimize and simplify maintenance in an industry that cannot afford downtime. For example, in



the food and dairy processing industry, downtime can become costly when food spoilage occurs and processing is not completed as planned. In an effort to keep maintenance time to a minimum, the *MEK-3001A* incorporates a plug-in relay encased in a transparent cover. This cover permits inspection of the circuit operation at any time as well as preventing the entry of dust or other foreign matter which may affect relay operation. The electronic liquid level control can be connected for all types of service. This control will monitor any liquid whose resistivity is between zero and 2 million ohms per centimeter cube. Shock hazard is completely eliminated inasmuch as the probe voltage is less than 12.5 volts and is isolated from the a-c power supply by a transformer.

Magnetic Field Control System. A magnetic field control system which permits highly accurate stabilization and control of magnetic fields in the range of 300 to 18,750 gausses, has been announced by Nuclear Magnetics Corporation of Boston, Mass., a subsidiary of The Perkin-Elmer Corporation. The system, utilizing the principles of nuclear magnetic resonance, controls magnetic fields by deriving error signals directly from the field, rather than from magnetizing coil voltage or current measurements. Called the NUMAR (registered trade-mark) magnetic field control system, model *C-7*, it can be used to control the magnetic analyzing field of a

(*Continued on page 36A*)



HUGHES semiconductors

Hughes offers one of the most comprehensive families of semiconductors in the industry. This gives you great freedom of selection—makes it possible for you to take advantage of characteristics peculiar to many devices. It means, also, that it is possible for us impartially to recommend (and to supply) specific Hughes semiconductors best suited to your requirements. Since diode selection is not confined to types derived from a single kind of production, you can choose from varying combinations of electrical or performance characteristics. Some of these are: High Conductance . . . High Back Resistance . . . Quick Recovery . . . High Temperature Operation. Whatever your circuit application, remember that, in every semiconductor product category, HUGHES QUALITY *means* HIGHEST QUALITY.

AT THE IRE SHOW

visit our display in booths 753, 755, 757. Our new N-P-N Fused Junction Transistors will be exhibited in operating demonstrations, together with a representative selection of germanium and silicon diodes from the extensive Hughes line. Meanwhile, for additional information, or descriptive product literature, please write:

HUGHES

SEMICONDUCTORS
PRODUCTS DIVISION
HUGHES AIRCRAFT COMPANY
International Airport Station, Los Angeles 45, California

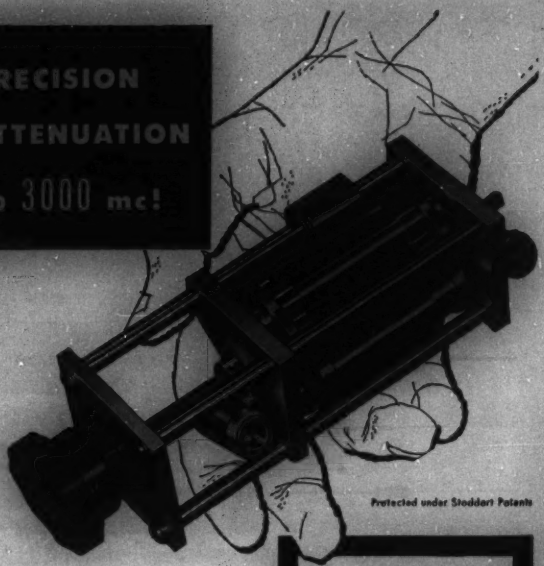
ALL DIODES MADE BY HUGHES ARE:

Moistureproof—Fusion-sealed in a one-piece glass envelope.
Rugged—Successfully withstand physical shock and vibration.
Stable—Mechanical and electrical characteristics remain stable throughout a long operating life.
All Diodes Tested—For electrical and mechanical characteristics.
Subminiature—Glass envelope: 0.265-inch by 0.105-inch, max.

HUGHES PRODUCTS

A DIVISION OF THE HUGHES AIRCRAFT COMPANY

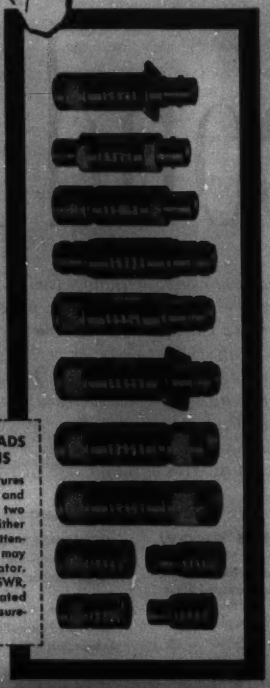
PRECISION ATTENUATION to 3000 mc!



Protected under Stoddart Patents

six-position
TURRET ATTENUATOR
featuring PULL-TURN-PUSH *action*

FREQUENCY RANGE: dc to 3000 mc.
CHARACTERISTIC IMPEDANCE: 50 ohms.
CONNECTORS: Type "N" Coaxial female fittings each end.
AVAILABLE ATTENUATION: Any value from 1 db to 60 db.
VSWR: 1.2 max., dc to 3000 mc/s, values from 10 to 60 db. As value decreases below 10 db, VSWR increases to not over 1.5.
ACCURACY: ± 0.5 db.
POWER RATING: One watt sine wave power dissipation.



SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATIONS

This new group of pads and terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles. For example, the two connector types, either male or female, can be mounted on the same attenuator pad, with or without flanges, so that it may serve as an adapter as well as an attenuator. Frequency range, impedance, attenuation, VSWR, accuracy and power rating are as designated above. Send for free bulletin entitled "Measurement of RF Attenuation."

STODDART aircraft radio co., inc.
6644-E SANTA MONICA BLVD. HOLLYWOOD 38, CALIFORNIA HOLLYWOOD 4-9545

New Products

(*Continued from page 32A*)

particle accelerator, thus producing accurate beam energy control. It gives high accuracies in analysis by controlling deflection magnets, and can be used to control the magnets of microwave spectrometers and mass spectrometers. If desired, the system can be used to control two mass spectrometers in tandem, thus approximately squaring the resolving power of a single mass spectrometer.

High Sensitivity Oscilloscopes with Large Screen Announced. Combining high sensitivity with large screen display, a new oscilloscope has been developed by Electromec, Inc., Los Angeles, Calif. Units are available with 17-inch and 21-inch rectangular tubes, designed for high resolution and long-range visibility. This

new development makes possible the detailed observation of complex wave forms and large quantities of data with minimum interpolation and reading error. The new Electromec Scope monitors and demonstrates complex signals in readable form, especially where input is of a low order of magnitude. In addition to the high sensitivity of 10 millivolts peak to peak for full scale deflection, other important features include ± 1 per cent linearity, stable d-c amplifiers, calibrated time base (from 10 microseconds per inch to 1 second per inch), and gain controls calibrated in peak to peak volts per inch. For further information, write to Electromec, Inc., Oscilloscope Department, 5121 San Fernando Road, Los Angeles, Calif.

Metal Mounts for Delicate Instruments. Using an isolated means of mounting delicate electronic and navigational instruments to provide maximum vibration protection and equipment stability in aircraft and missiles, has been announced by the K. W. Johnson and Co., Inc., Dayton, Ohio. Johnson Metal Mounts are a double damping system where a circular coil spring tempers the motion of a convex-concave spring to lift the efficiency of the damping to 95 per cent. Usually, four of these mounts are attached to the base of all electronic components in the aircraft—

(*Continued on page 40A*)

This IS THE SERVICE ENTRANCE CABLE FOR TODAY'S HIGHER LOADS

WITH

TRIANGLE RH-RW INSULATION

Today's highly electrical homes demand a Service Entrance Cable with the ability to handle much heavier loads than ever before. That's why Triangle changed to a better insulation—Type RH-RW. All Triangle Service Entrance Cable is now furnished with this fine insulation. Type RH-RW insulation exceeds Underwriters' specifications for either RH or RW.

Triangle Service Entrance Cable, with Type RH-RW insulation, is far and away your best buy. Not only does Triangle Service Entrance Cable incorporate today's highest quality insulation, the cable also has these outstanding advantages:

1. "Silver" outer cover.

Clean, smooth, good-looking, takes and holds paint, easy to strip.

2. Tough and weatherproof—yet flexible.

The cover and inner construction of Triangle Service Entrance Cable are made for *long-lasting* ruggedness and flexibility. The outer braid is a unique combination of glass filaments and long-staple cotton for long life and a guarantee against peeling, cracking or festooning. Inner layers are made from the best available material—so good, that you can "feel" the quality of this cable the minute you handle it.

It Must Be Right — The Trade Mark of TOP Quality — TRIANGLE ®

TRIANGLE CONDUIT & CABLE CO., INC.

NEW BRUNSWICK, N. J.

Manufacturers of Arteries for Electricity, Liquids and Gases

WIRE · CABLE · CONDUIT · PLASTIC PIPE · BRASS AND COPPER TUBE

FOR HEAT
RESISTANCE
TO 200°C

Silicone Insulated Wires and Cables
0-5,000 volts
Consult our Engineering Department

Collyer
Insulated Wire Co.
245 Roosevelt Ave.
Pawtucket, R. I.

(Continued from page 36A)

up to 500 in a fighter plane, and over 3,000 in bombers. The basic function of the mount is to isolate and attenuate the structural vibration originated by the engines, propellers, jet turbines, and rough air. Resonance is a condition common with all materials, and it is in direct relationship to the inherent qualities and composition of the material involved. The principle of any isolator is to maintain this resonance point at low frequency so that is will cover the higher ranges with maximum efficiency.

Pole Top Bracket. A new pole top bracket for mounting post-type distribution insulators is announced by the Lapp Insulator Co., Inc., Le Roy, N. Y. The bracket is designed to use with Lapp's recently introduced distribution post insulators (20- and 27-kv ratings) and for subtransmission service with line-post insulators up to and including 35 kv. It is recommended for use with post-type insulators in conventional pole-top construction with crossarms, or for an optional low-cost method of construction with insulators mounted horizontally directly to pole. The unit is pressed-steel ribbed for increased strength, and hot-dip galvanized.

New Wiring Device. Have you ever been frightened by strange noises in or about your house in the dead of night, or stumbled around in the dark looking for a light switch. Now you can eliminate these anxious moments by instantly flooding your house and ground with light controlled by silent bedside switches. This remote control of all interior and exterior lighting is made possible by Remcon, a new wiring device introduced by the Pyramid Instrument Corporation, Lynbrook, L. I., N. Y. Electrically heating the bathroom before moving from bed, silencing the radio from the next room, turning on the porch light from the kitchen, starting the attic fan from a kitchen switch and lighting the nursery from the bedroom are among the many applications for every part of the house. Remcon requires no centrally located external transformer; each circuit is a separate self-contained unit completely independent of any other. All the electrician has to do is fit a Remcon unit into the outlet

(Continued on page 40A)

*1/10 OF 1%...LABORATORY STANDARDS

the primary instrument standards the world over... for instrument checking and maintenance, and wherever measurements must be made to a high degree of accuracy. Available as D-C Voltmeters and D-C Ammeters, and as A-C and D-C Voltmeters, Ammeters, and Single Phase Wattmeters.

*1/4 OF 1%...PORTABLE STANDARDS

the portable reference standards, for checking instruments, certified test work, and laboratory measurements. Available as A-C and D-C Voltmeters, A-C and D-C Ammeters and Milliammeters, D-C and Single Phase A-C Wattmeters, Poly Phase Wattmeters, Power Factor Meters, Frequency Meters and Phase Angle Meters.

*ACCURACY RATED

Weston's comprehensive selection of accuracy ratings enables you to choose instruments which *exactly* meet your measurement needs from every standpoint...*conservatively rated accuracy, long life, low cost.* For literature, consult your local Weston representative, or write direct.

WESTON Instruments

WESTON Electrical Instrument Corporation

614 Frelinghuysen Ave., Newark 5 N. J. — *A subsidiary of Daystrom, Inc.*

*1/2 OF 1%...WORKING STANDARDS

the rugged portables for general test work where long, readable scales and high shielding are desired. Available as D-C Voltmeters, Ammeters, Milliammeters and Volt-Ammeters; and as A-C Voltmeters, Ammeters, Milliammeters, and multi-range Ammeters and Voltmeters; A-C and D-C Single Phase Wattmeters.

*1% ...FIELD AND SHOP INSTRUMENTS

Miniature D-C portables for accurate measurements in shop or field. Available in all required ranges as D-C Voltmeters, Millivoltmeters, Ammeters, Milliammeters, and D-C Volt-Ammeters.

BIDDLE *Instrument News*

Biddle Motor and Phase Rotation Tester

(Dual Purpose)

With it you can . . .

- **Determine the direction of rotation of electric motors before they are connected to the line.**
- **Determine the phase rotation or sequence of energized power circuits.**

Here is a positive means for determining which motor leads must be connected to certain conductors of a supply system to insure that the motor will rotate in a prescribed direction when energized.

This device will permit the electrical contractor or industrial maintenance electrician to permanently connect and tape the terminals of the motor being installed, without having to first energize the motor by a temporary "hook-up" from a power source, if available, to determine its rotation.

Housed in a sturdy oak case 12¼" x 8¼" x 4¼" this compact unit weighs approximately 10 pounds and is supplied complete with 3 line and 3 motor leads which store in the compartments either side of the instrument panel.

For complete details write for **Bulletin 80-EE.**

Biddle Dielectric Test Set Model 1-40 KV

—for measuring d-c current at voltages up to 40 kv when applied to the insulation of such equipment as generators, transformers, bushings and cable.

Carefully considered safety features, excellent output voltage regulation, simple operation, compact design, and facilities for making voltage and current measurements at either polarity have been incorporated in this test set.

The set has a current rating of 25 milliamperes at short circuit, and current measurements can be made down to 0.5 microamperes which is the first division on the microammeter.

Overall dimensions are: height 19½ in., width 13½ in., depth 20 in., weight 120 lbs. All high voltage components are oil immersed.

For complete details, description, specifications, and prices, write for **Bulletin 22-EE.**

James G. Biddle Co.
1316 Arch St., Phila. 7, Pa.

Gentlemen: Please send me

☐ **Bulletin 80-EE**
☐ **Bulletin 22-EE**

NAME

JOB FUNCTION

COMPANY

ADDRESS

B-600

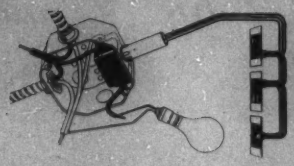
JAMES G. BIDDLE CO.

• ELECTRICAL TESTING INSTRUMENTS
• SPEED MEASURING INSTRUMENTS
• LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

New Products

(Continued from page 38A)



box and match the three wires of the unit to the three wires of the switch. Six volts are required to activate the outlet, number 18 bell wire replaces the heavy BX cable normally run from outlet to switch and installation becomes simple and economical.

Hi-Fi Tape Recorder Produced. Production has been started on a new Radio Corporation of America (RCA) high-fidelity tape recorder, the first to be manufactured by this company. The demand for tape recorders, for the home and business, could easily be a $100-million-a-year industry in the near future. The Judicial, model *7TR3*, a 3-speaker, push-button portable incorporates a number of new engineering advances and is the forerunner of a complete line of RCA Victor tape recorders. Other models in the line are scheduled for introduction within the next several months. RCA has marketed magnetic tape recorders for several years. However, previous models were manufactured by outside firms according to RCA specifications. Chief among the new features of the Judicial is a newly-designed amplifier that is perfectly matched to the magnetic head of the tape transport and the exclusive voice-music switch. This feature permits the selection of the best sound characteristics for either voice or music recording. The newly developed amplifier has an output of 2 watts undistorted. It has three loudspeakers and will record and play back at either $7^1/_2$ or $3^3/_4$ inches per second.

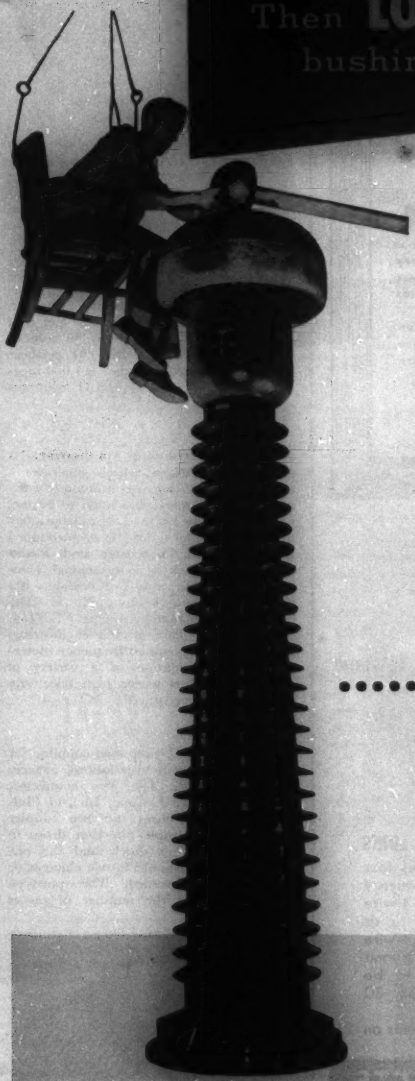
Dual Output Voltage Magnetic Amplifier. Announcement of the dual voltage range magnetic amplifier regulated d-c power supply, *MR1040-30A*, with a voltage output of 5 to 30 volts and 10 to 40 volts at 30 amperes has been made by Perkin Engineering Corporation, 345 Kansas Street, El Segundo, Calif. This tubeless unit contains no moving parts and has a dual wide-range output voltage in one compact container. For further literature and specification sheets, write Perkin Engineering Corporation on company letterhead to the attention of Philip Diamond.

Digital Voltmeters Feature Automatic Continuous Calibration. Electro Instruments, Inc., San Diego, Calif., manufacturer of precision instruments, has announced an important improvement in their digital voltmeters. The company's voltmeters are used to measure, display,

(Continued on page 42A)

Want smaller, lighter transformers and oil circuit breakers?

Then LOCKE'S TYPE U is the bushing for your apparatus!



FOR 92 KV AND ABOVE

Type U is the high voltage apparatus bushing which gives you all the desirable electrical characteristics of earlier bushing designs PLUS the added advantages of smaller dimensions and lighter weight.

For example, Locke's 161 KV Type U bushing is 6¼" *smaller* in ground sleeve diameter, and 590 lbs. *lighter* than its equivalent of earlier design. There is no sacrifice in dielectric strength.

Specify Type U for your apparatus, and chances are good you'll find that your transformers and oil circuit breakers will come to you accordingly smaller and lighter.

For replacement purposes, Type U is ideal because you can handle it more easily during installation . . . and less storage space is required.

Consult your apparatus manufacturer, or send today for complete descriptive literature.

Unusual Radio Noise Test Procedure . . .

Photo shows radio noise test of 287.5 KV Type U bushing. (Today, radio noise is almost zero.) *Each* and *every* Type U bushing is radio noise tested both *before* and *after* one minute ASA standard high potential dry withstand test. This procedure is unusual as the common industry practice is to test on a selected sample basis. Locke makes this and other extra tests to insure uniform bushing reliability.

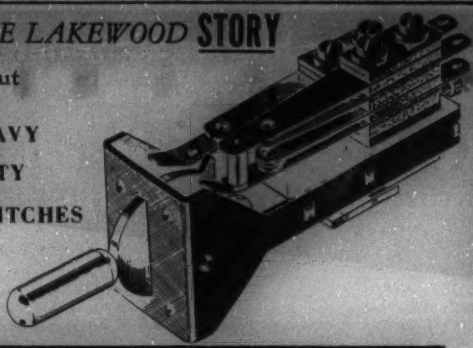
LOCKE

LOCKE DEPARTMENT
GENERAL ELECTRIC COMPANY
BALTIMORE, MARYLAND

THE LAKEWOOD STORY

About

HEAVY DUTY SWITCHES



QUALITY • ENDURANCE • DEPENDABILITY

That's OUR story in three words. We have found in the past that quality is the keynote of success. Most customers remember the quality long after they have forgotten the price, whether it be high or low. Quality of a product insures dependable operation for a longer period of time. The three words therefor go hand in hand.

We have stressed the importance of quality in our shop until it has now become a second nature with our entire staff. You will find that we are competitive in price . . . competitive in service . . . and far ahead in Quality—Endurance—Dependability.

For more information write to:

THE LAKEWOOD CO.

264 PRAIRIE AVE. CRYSTAL LAKE, ILLINOIS

MANUFACTURERS OF ELECTRO MECHANICAL PRODUCTS

FOUR-CHANNEL CARRIER-TELEPHONE TERMINAL FOR RADIO LINKS

This is a miniaturized unit of advanced design which provides four voice channels on a frequency-division basis above a voice-frequency order-wire channel. Each of these five channels is provided with a 4-wire 2-wire termination and a voice-frequency ringing circuit for d-c or 20-cycle signals. Adjustable attenuators are provided in the 4-wire side of all channels, and a built-in test oscillator and meter permit complete line-up, maintenance and trouble-shooting checks to be made. Channel levels are from −9 to 0 dbm and line levels from −30 to 0 dbm. Channel width is 300 to 3500 cycles within 1 db.

This unit is only 5¼″ high by 19″ wide by 14″ deep. It mounts on a standard rack and operates from 115 volts 50-60 cycles a.c.

RADIO ENGINEERING PRODUCTS

1080 UNIVERSITY ST., MONTREAL 3, CANADA

TELEPHONE UNiversity 6-6887 CABLES RADENPRO MONTREAL

New Products

(Continued from page 40A)

and, if desired, record a-c and d-c voltages automatically. Measurement is accomplished by comparing the unknown voltage with an extremely stable reference. This reference is incrementally varied by automatically switching decades of precision resistors arranged in a Wolff-bridge circuit. Formerly, calibration of the instrument was done manually. Now, through a new circuit design, all Electro Instruments Voltmeters are continuously calibrated automatically. Stability is 0.01 per cent from 40 to 125 F with only 30 seconds warm-up time required for 0.01 per-cent accuracy. Input impedance is 1,000 megohms on the lowest scale and 11 megohms on other scales.

Wide-Band Frequency Synthesizer. A frequency synthesizer which generates a single frequency that is continuously variable from 30 cycles per second to 30 mc, and which may be used as a laboratory frequency standard, has been introduced by the Federal Telephone and Radio Company, division of International Telephone and Telegraph Corporation, 100 Kingsland Road, Clifton, N. J. The instrument, designated as type *FT-XUA*, is ideal for problems of filter engineering, testing crystals, precision frequency metering, and investigation of a variety of electrical elements where high selectivity and stability are required.

Cable Trough. A simplified coupling for cable trough speeds installations, reduces installation costs. The new connector, announced by T. J. Cope, Inc., of Philadelphia, Pa., secures the two coupler blanks with a simple pin that drops in place. Assembly is quick and the pin can be removed should future changes or expansions be needed. The pin-type coupling reduces the number of pieces

(Continued on page 50A)

CLAD SWITCHGEAR

Combines most advanced breaker design with proven advantages of Metal-Clad construction

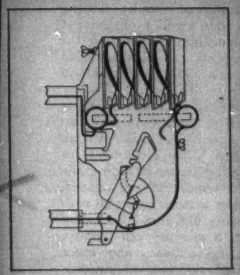
Modern, functional in appearance, Federal Pacific Metal-Clad Switchgear design is being proved over and over again in a rapidly increasing number of trouble-free installations. Completely assembled, wired, and adjusted at the factory—Federal Pacific Switchgear is thoroughly tested before shipment.

MOST ADVANCED MAGNETIC AIR CIRCUIT BREAKER DESIGN—utilizing Solenarc principle of arc interruption for exceptionally fast, positive arc extinction. The reliability of these breakers has been field-tested in hundreds of installations and their interrupting ability proved by exhaustive laboratory tests.

FLEXIBILITY—removable breakers and associated equipment are installed in individual free-standing enclosures and bolted together to form complete switchgear assembly...permits easy field installation of additional units.

SHEET STEEL BARRIERS—divide section interiors into compartments isolating breakers, busses, instrument transformers, and cable terminations...permits complete accessibility...safeguards personnel from adjacent live circuits.

SHIPPED READY FOR INSTALLATION—overall assembly can be divided into shipping sections for convenient handling by purchaser.



Solenarc Principle of Arc Interruption—Arc moves upwards between chamber plates and is formed into a series of rapidly expanding loops. As a result of extremely fast arc elongation and more efficient utilization of the arc chamber cooling surfaces—circuit interruption occurs at or near the first current zero.

NEW Scranton Plant—specially designed to provide the latest in switchgear manufacturing facilities—this spacious new plant consolidates Federal Pacific's assembled switchgear activities in one location.

ELECTRIC COMPANY
50 Paris Street, Newark 1, N. J.

I'm DALOHM...
You can depend on the expanded line of
TYPE DCH
HERMETIC SEALED RUGGEDIZED
DEPOSITED CARBON RESISTORS
NEW smaller sizes — NEW wattage ranges
Ideal for use in UHF equipment where only the optimum of quality may be tolerated.
Completely high temperature alloy solder sealed in envelope of non-hydroscopic ceramic. Ruggedized for incorporation into snap-in clips. Production tested for resistance to thermal shock, salt-water immersion, and resistance to humidity.
DCH-⅛, ⅛ watt; DCH-¼, ¼ watt; DCSH-½, ½ watt; DCMH-½, ½ watt; DCH-½, ½ watt; DCH-1, 1 watt; DCH-2, 2 watts.
• Resistance ranges to 200 megohms
• Temperature coefficient 140 PPM to 500 PPM per degree C
• Standard tolerance 1% (other tolerances available) Meet MIL-R-10509B (proposed) Specifications
Write for Bulletin R-57A
Export Dept.: Pan-Mar Corp 1270 Broadway, New York 1, N.Y.
1312 28TH AVE., COLUMBUS, NEBRASKA, U.S.A. Phone 2139
In Canada: Charles W. Pointon, Ltd., 6 Alcina Ave., Toronto

FLINT
developed
designed
detailed
fabricated
this unique Triple-Circuit Tower
The completely integrated service offered by Flint made this unusual tower possible. From original idea to actual erection, Flint was there. When you build anything with galvanized structural steel why not take advantage of this unusually complete Flint service.
FLINT STEEL
TULSA
MEMPHIS
Sold Competitively Everywhere

New Products

(*Continued from page 42A*)

required for one connection from 13 to 3. Nuts, bolts, and washers are replaced by only two pins. The joint is completed with a plate that fits both over and under the bottom of the trough to protect the cable. Cable trough is inexpensive, simple to install, flexible in awkward areas, and provides direct access to cable for inspection. New lines often can be run simply by laying a line in existing trough. This pin-type coupler is one of the important improvements made in the new Cope *70,000* series.

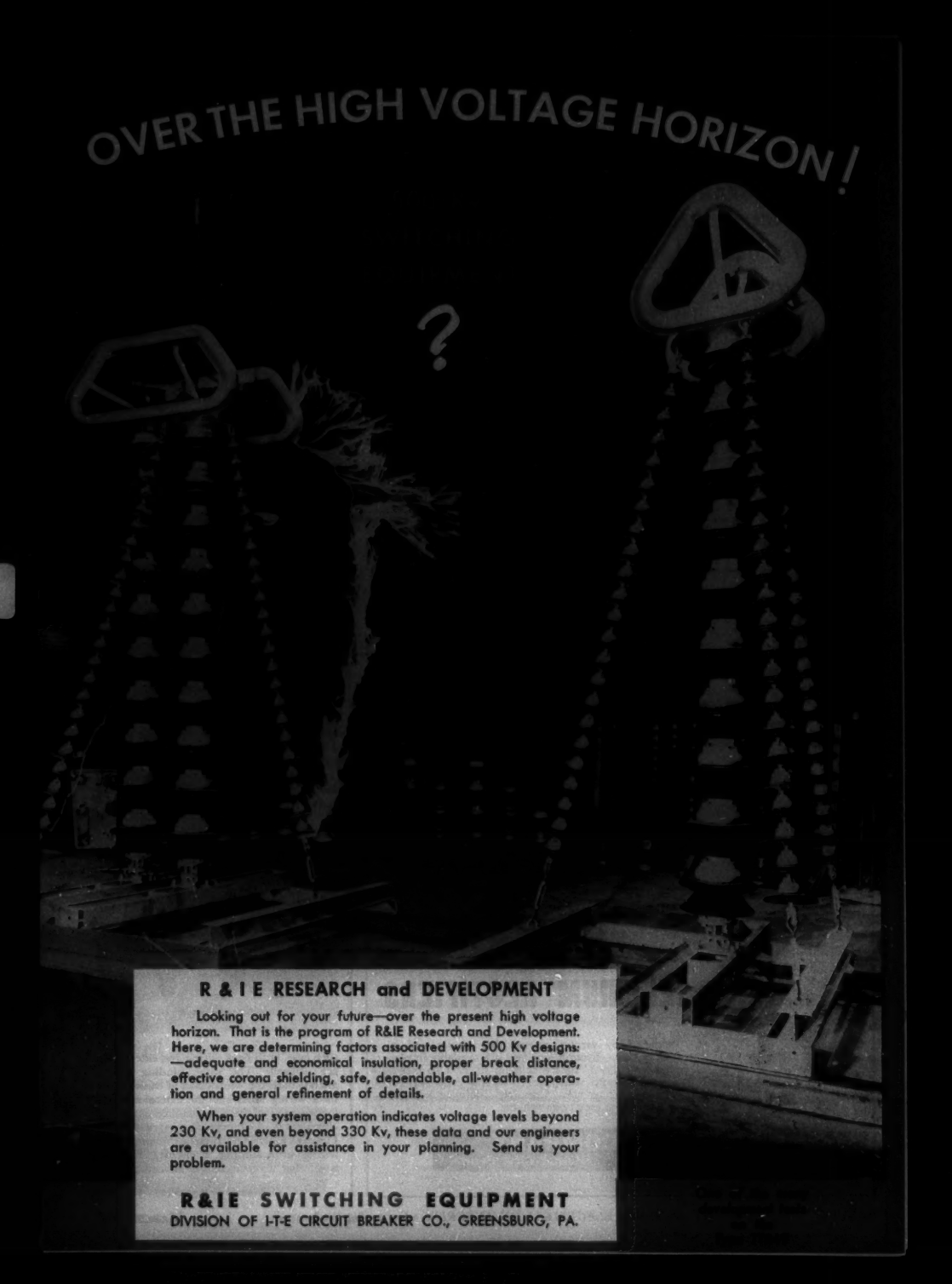
Automatic Oscillograph. A 22-channel, automatic oscillograph has been announced by General Electric's Instrument Department. Greater versatility of the new oscillograph, designated the *PM-21*, is obtained by the accommodation for 1 to 22 bifilar-type and 4 zero-trace galvanometers. One bank of bifilar galvanometers (11) can be replaced with as many as 60 wound-coil galvanometers for recording ON-OFF operations. The equipment can be converted easily to a portable, general-purpose oscillograph with paper speeds up to 500 feet per minute for use in stage testing. Another major feature of the *PM-21* is the easy-access design, which permits simple maintenance of vital parts.

Beltone's Hearing Glasses. Hearing with two ears now is being offered to the hearing handicapped. With new hearing glasses by the Beltone Hearing Aid Company the direction of sound can be determined clearly, even in noisy situations, and receive sound in its full dimension. The Beltone hearing glasses, called Hear-N-See, consists of two separate and complete hearing aids built into the temples of the eye glasses. With true binaural hearing the hearing handicapped can participate in normal conversation with greater ease and confidence.

Sounds of danger, such as screeching brakes or defective machinery, now can instantly be determined and evaded. The Beltone Hear-N-See instrument includes all operating parts, including the receiver, in the temple of eye glasses. Each temple of the frame is equipped with a complete hearing aid circuit including three transistors, a mercury cell battery, printed circuit, microphone, and other components. Each side has volume controls which can be adjusted to the hearing ability of the ear it serves.

Miniature Ruggedized D-C Millivoltmeter. A new, low-level d-c vacuum-tube voltmeter (VTVM), small enough to be built into any equipment panel, reads from 500 microvolts to 300 volts d-c with an accuracy of 2 per cent of full scale. Designated model *J*, this addition to the Trio Laboratories incorporates a unique chopper amplifier circuit which offers exceptional stability over a wide range of environmental conditions. Ambi-

(*Continued on page 52A*)



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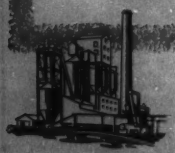
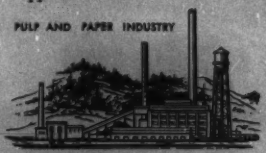


CHEMICAL PROCESS AND STEEL INDUSTRY

POWER PLANTS



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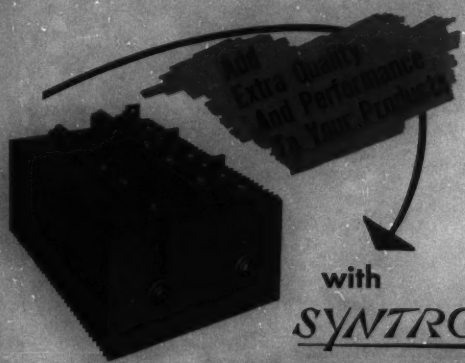

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SYNTRON COMPANY

440 Lexington Avenue Homer City, Penna.

New Products

(Continued from page 50A)

ent temperatures of 71 C and line voltage changes as great as 40 per cent of nominal will not cause appreciable changes from room temperature readings. Designed for panel mounting by means of four self-locking threaded inserts, it is ideal for field tester use and for built-in monitoring and trouble-shooting operational equipment. For additional information write to J. S. Salz, Trio Laboratories, Inc., 3293 Seaford Avenue, Wantagh, N. Y.

Wiring. Pressure plate back wiring has been introduced by Harvey Hubbell, Inc., for faster, easier wiring at minimum installation cost which places emphasis on the security and safety of the connection. This method provides time-saving, labor-saving convenience of modern back wiring plus the safety of a pressure plate screw connection. Fig. 1 shows how the Hubbell pressure plate mechanism is designed. The stripped wire, when inserted through the reinforced back wiring holes (Fig. 2), locates between the terminal plate and the pressure plate which, as the screw is tightened, pressure-grips the wire securely. Actually, the electrician has a choice of using back wiring or side wiring. He can either insert the wire through the back wiring holes and pressure-grip the wire as the diagram indicates, or he can loop the wire around the side binding posts in the conventional manner. Both of these methods find practical application when a circuit needs to be extended. In

such case, both back wiring and side wiring are utilized. The same binding screws anchor both the wires inserted through the back wiring holes and the extension wires looped around the side binding post, thus eliminating the need for extra splices. Fig. 3 illustrates pressure plate back wiring in extending a circuit. Hubbell is offering, free of charge, an actual pres-

(Continued on page 56A)

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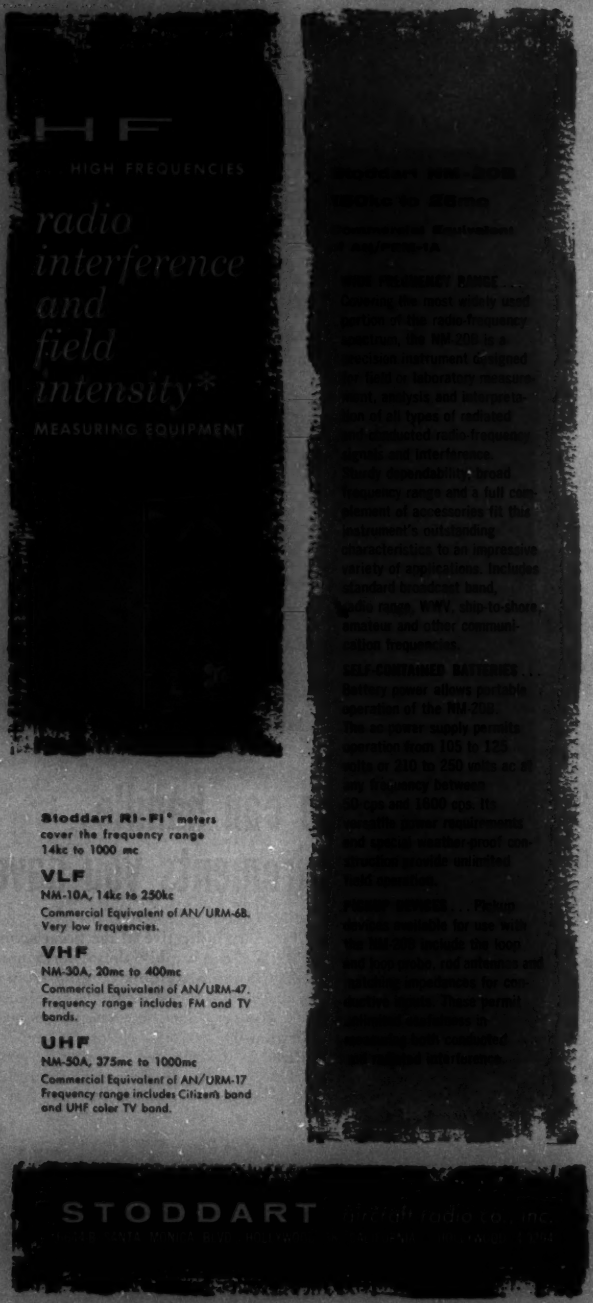
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UHF
NM-50A, 375mc to 1000mc
Commercial Equivalent of AN/URM-17 Frequency range includes Citizen's band and UHF color TV band.
STODDART

New Products

(*Continued from page 52A*)

sure plate contact assembly attached to a molded base so that customers can see and demonstrate this new wiring system. These free demonstration units may be obtained by writing Harvey Hubbell, Inc., Sales Promotion Dept., Bridgeport, Conn.

Polyethylene Resin. A new polyethylene resin that produces unbreakable molded articles with greater rigidity, more wear-resistant surfaces, and higher gloss has been announced by Bakelite Company, Division of Union Carbide and Carbon Corporation. The new resin is Bakelite polyethylene *DXM-103*. The high gloss of this material is created by the resin's excellent flow characteristics in the mold. The easy flow also eliminates flow lines characteristic of ordinary polyethylene molding materials. In the packaging field, it is expected to make possible the production of caps and closures with greater resistance to staining by chemical contents. This *DXM-103* is a dense material with improved tensile strength, increased surface hardness, improved resistance to staining, and slightly reduced permeability.

Light-Weight, 8-Inch Television Picture Tube. The Radio Corporation of America (RCA) Tube Division has developed a compact 8-inch television picture tube, type *8DP4*. The tube has a rectangular glass envelope, weighs only 3 pounds, and is less than 11-inches long. Characteristics of the tube make it suitable for use in small-size television receivers, as well as in service monitoring instruments and in industrial television equipment. Its length has been reduced to $10^{3}/_{4}$ inches by employing wide angle, 90-degree deflection.

TRADE LITERATURE

The 400 American Standards in the Electrical Field. A 60-page booklet which indexes and describes each American Standard in the electrical engineering area. It is designed to help the user and prospective purchaser find the applicable standard on the product in which he is interested. The booklet also gives briefs of each of the current International Electrotechnical Commission recommendations; a listing of all projects under the jurisdiction of the Electrical Standards Board—including officers, sponsors, and scopes of these projects. It also contains general information on the work of the American Standards Association, the Electrical Standards, Board, and the International Electrotechnical Commission. It explains how and why American Standards are de-

(*Continued on page 60A*)

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"National" brushes offer a complete line of proved grades to meet every condition of operation – standard or special – all through the mill and mine. Here, for example, are the grades recommended for electric utility and sub-station equipment – with the services of a National Carbon brush specialist always available to help you in the final selection for each unit.

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Universally recognized leaders in AC field excitation equipment.

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Standard grades, choice being determined by machine characteristics.

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Metal-graphite slip-ring formulation, applied according to current density.

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Trade Literature

(*Continued from page 56A*)

veloped and describes the benefits to manufacturers, users, and the general public. Free as long as they last from the American Standards Association, 70 East 45 Street, New York 17, N. Y.

Heat Exchangers Catalogue. Users of shell and tube type heat exchangers will find a new 32-page technical catalogue, published by E. C. Cooley Company, a valuable guide to efficient equipment selection. This new catalogue uses a carefully prepared system of easy-to-understand curves and examples of heat exchange performance under varying field conditions. Also covered in the catalogue are reliable comparisons of the various types of shell and tube heat exchanger equipment. Copies of the Cooley technical catalogue may be obtained without cost from the company's main office: 1186 Folsom Street, San Francisco, Calif.

Aluminum Bronze Alloys Booklet. W W Alloys, Inc., Division of Fansteel Metallurgical Corp., has issued a 32-page booklet, "W W Premium Quality Aluminum Bronzes." Basic information on the properties, composition, and functions of aluminum bronze alloys are furnished. Engineering data on each grade of W W aluminum bronze is contained in a 17-page section. A specification index chart identifies W W grades with various Government and Technical Societies' specifications. Also included are six pages of drawings and tables of machining recommendations, information on engineering, and metallurgical consultation services. Copies of booklet number *15.100-1* are available free upon request. W W Alloys, Inc., 11673 Cloverdale Avenue, Detroit, Mich.

Design of Nickel Magnetostriction Transducers. A new booklet entitled "Design of Nickel Magnetostriction Transducers" has been issued by the Development and Research Division of The International Nickel Company, Inc. The booklet summarizes practical experiments to guide the engineer toward a workable design in exploring new fields in the sonic and ultrasonic regions. A magnetostrictive transducer is used to convert electrical input energy to mechanical output energy or mechanical input energy to electrical output energy. The booklet is available without charge by writing to the Readers Service Station, The International Nickel Company, Inc., 67 Wall Street, New York, N. Y.

McGill Catalogue. Technical and descriptive data on the Levolier line of electrical specialities are contained in a new 52-page catalogue prepared by the McGill Manufacturing Company, Inc. The material has been grouped under three major headings: switches, lampholders, and lamp guards. Text descriptions of

(*Continued on page 66A*)

the "Long Haul"

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you advantages like these:

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- Reduced tower installation costs
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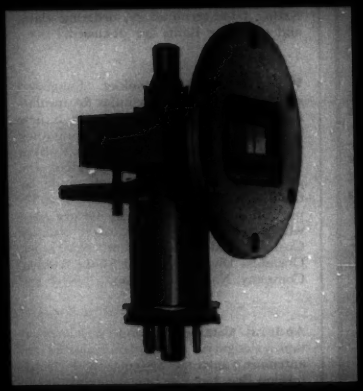

Philco CLR-7 Microwave ... passive ... rugged construction reliable! Built to provide ... failure, trouble free, ... operation on long hops.

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- Reduces typical power line distortion to less than 0.3%
- Furnishes 1.4 KVA of distortion-free power
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- Recovery time less than 1/50 cycle
- Provides additional 4 KVA of ±1% electromechanically regulated power
- Electromechanical time constant only 0.6 seconds
- Electromechanical regulator, unlike usual magnetic voltage stabilizer, introduces no distortion or phase shift

Here at last is the ideal solution to the disturbing problem of harmonics and low frequency noise appearing in 115 V., 60 cps power sources. In one compact package, every laboratory can now obtain *both*

1) distortion-free, regulated power when needed, and simultaneously

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In addition to its general laboratory utility, this instrument is ideally suited for preventing instability and inaccuracy in a.c. computer system nulling operations. Many other applications. 230 V. model also available. Immediate delivery. $1,689 f.o.b. Carlstadt, N. J. Write for details.

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Trade Literature

(*Continued from page 60A*)

each Levolier unit covers its recommended uses, advantages, and method of operation. Photographs illustrate features of construction and operation, and schematic wiring diagrams show the various switching arrangements available. Copies may be obtained by writing to McGill Manufacturing Company, Inc., Electrical Division, Valparaiso, Ind.

Sound Systems. The David Bogen Company, Inc., has published a 24-page reprint of a series of 3 highly informative articles covering the fundamentals of sound systems operation and installation. "What You Should Know about Sound Systems," was prepared as a primer for those with little previous knowledge of sound, and clearly presents basic facts on amplifiers, microphones, speakers, impedance matching, systems planning, as well as installation practices. For those responsible for the selection and installation of sound equipment, this booklet will serve as a valuable guide. Copies of the 24-page reprint are available from David Bogen Company, Inc., 29 Ninth Ave., New York, N. Y., for ten cents per copy.

Industrial Fan Catalogue. A new 72-page illustrated catalogue, Bulletin *5,306*, describing the new series *706* industrial fans which provide complete full-range coverage of industrial air and material handling requirements is now available from American Blower Corporation, Detroit 32, Mich. The catalogue describes the features of the new fans. A special section describes the new packaged industrial fan, a completely self-contained unit complete with fan, motor, and drive unit. Rating table terminology, ordering data, and operating limits are discussed.

Wire and Cable Booklet. Suggested rubber compounding formulas for insulating wire and cable are given in a new booklet prepared by the Naugatuck Chemical Division, United States Rubber Company. The booklet also gives the properties of rubber chemicals made by the division for this application. The 32-page illustrated booklet may be obtained without charge by writing to the Rubber Chemical Sales Department, Naugatuck Chemical Division, United States Rubber Company, Naugatuck, Conn.

Andrew Catalogue. Andrew Corporation, designers and manufacturers of antennas, antenna systems, and transmission line, has announced publication of a 100-page catalogue containing product description and engineering data of over 500 of their products. System engineering data and related information that engineers specializing in this field of electronics will find informative covers some 20 pages. The catalogue is available upon request from the Andrew Corporation, 363 East 75th Street, Chicago, Ill.